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HERE'S WHAT PRACTICAL STEEL MEN THINK OF L&N FURNACE PRESSURE CONTROL

In 1932, a certain corporation installed L&N Pressure Control on one of their West Coast open-hearths. A year later, 3 additional furnaces went under automatic control, and the succeeding year, 4 more.

Then, in 1935, one of their mid-western O.H. superintendents spotted an L&N Pressure Control on one of his special reheating furnaces. Due to a slump in business, the furnace wasn't operating. He transferred the control to an O.H., and analyzed the results. Within a year, 28 controls were at work in his and another of the company's shops... a year later, 28 more. Now this company has more than 80 L&N Pressure Controls on their O.H. furnaces.

Another firm equipped an O.H. with L&N Control in 1931. At the end of one year, two additional controls were installed. Operating efficiency was so improved that two more controls went in during 1933, and another has just been ordered.

Or consider the company which, in 1934, selected 4 open-hearths for test operation. On one they installed an L&N Pressure Control; on the others, the controls of three other manufacturers. Operating costs were carefully compared, checked and tabulated. The following year, this company ordered two more L&N Controls. In 1936-37-38 they added a number of new open-hearths—and L&N Pressure Controls went on *every one*. The first 1939 order is in.

This practice of making an initial installation, studying the result, then extending control to additional open-hearths, indicates clearly what the men responsible for making good steel, at low cost, think of L&N Furnace Pressure Control. If you haven't read our bulletin describing this equipment, we'll be glad to send you one. Just write to the address below and ask for Bulletin 600-A.

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BLAST FURNACE

Skip and Top Direct Current

CONTROL

▲ BLAST furnace charging has developed by leaps and bounds in recent years and the importance of charging equipment and attendant control becomes of increasing importance with the use of larger furnaces.

In the year 1840, almost 100 years ago, there were 804 blast furnaces in operation in the United States. Today, there are only 237 furnaces listed with approximately one half that number in operation. In 1840 the combined output of those 804 furnaces was 286,903 tons. Today one furnace can produce as much iron in eight months as those entire 804 furnaces produced in one year.

A modern 1000-ton furnace is capable of turning out under favorable conditions, as much as 1400 tons in 24 hours. Over two hundred tons of hot metal, or sufficient to build two large locomotives, comes pouring from the iron notch every four hours. A battery of three or four blast furnaces, with one held as spare or under repair, is sufficient for the average steel plant. An emergency shut down of one of these means an interruption of 33 to 50 per cent in output.

Few people outside of the designers and operators appreciate the size of a modern blast furnace and have any conception of the amount of material that is continuously charged into the monster, so it might be well to indulge in a few round numbers in order to set the stage for the discussion on blast furnace charging which follows.

A 1000-ton furnace has a working volume of approximately 40,000 cu. ft. The height inside is about 100 ft. The inside diameter is about 25 ft. at the hearth, 28 ft. at the bosh, tapering to 20 ft. at the top. The walls are 3 ft. 6 in. thick and are water-cooled in the hotter lower portions.

Under normal operation such a furnace produces about 200 tons of iron every four hours. For every ton of metal produced we must charge approximately 3½ tons of ore, coke and stone. One of the most amazing

Presented before A. I. & S. E. Birmingham District Section Feb. 27, 1939

By H. L. WILCOX, *Assistant Chief Engineer*

Electric Controller and Manufacturing Company

CLEVELAND, OHIO

FIGURE 1—View of recently built 1000-ton blast furnace in which are incorporated the modern improvements.

facts to the uninitiated is that the weight of air blown into a furnace is from 3 to 3½ times the weight of iron produced or roughly equal to the weight of the ore, coke and stone charged. A 1000-ton furnace operating at full capacity requires about 70,000 cu. ft. of air per minute at a pressure of 20 to 25 lb. per sq. in. While 125 to 150 horsepower is expended in charging the solid materials, it requires 6000 to 7000 horsepower to provide the blast.

Now let us mention briefly the main units used in handling the ore from the stock pile to the furnace. The stock pile of ore and stone is usually near at hand having been brought there by boat or train. An ore bridge is used to transfer the ore and stone from the stock pile to a bottom dumping lorry car which travels along the ore trestle and deposits this material into the bins. These bins are located in a line adjacent to the furnace and running over the skip pit. The bottom of each bin is equipped with manually operated gates. A scale car, running on a track under the bins, is loaded by weight and carries its burden of ore and stone over to the skip bucket in the pit. The coke bunker is usually located directly over the pit so that the scale car is not required for transferring coke from the bunker into the skip bucket. The buckets, having capacities from 160 to 220 cu. ft., are usually filled full with coke and smaller volumes of ore and stone are used to give the proper proportion. The coke is passed over a screen or grizzly before going into the skip bucket in order to remove the coke breeze or fine dust, as this would interfere with the draft and operation of the furnace. This coke breeze is elevated to a hopper for loading into cars, and removed for other purposes. Some times the coke is weighed or measured out by volume so as to exactly fill the bucket thereby eliminating the chance of running it over. In other cases the stone also is stored over or adjacent to the pit so that, while the scale car is used to weigh the charge, it is not necessary to move the scale car for the stone load.

Everything is being done to cut down the amount of work done by the scale car operator because in most cases this is the bottleneck of the complete operation.

FIGURE 2—All master switches and indicators for charging control are located on a panel in the skip pit.

Scale cars are made with two compartments, sufficient for filling two skip buckets so that, if the coke and stone are stored above the pit, it is only necessary for the scale car operator to make trips for ore and in case of forced operation, two men may be employed for the skip charging, one taking care of the stone and coke while the other man is bringing up the ore.

The above by no means covers all the modern ways of charging the skip buckets. Belt conveyors may be used to fill the buckets after the proper amounts of each material are charged on the belt. Contact-making weigh scales may also be used to interrupt the flow of material into the bucket when the proper weight has been obtained.

When the skip bucket has been loaded and indicating lights show that everything is in readiness, the scale car operator throws his master switch over in the direction of the loaded bucket, then he may go about his work preparing the next load. The skip hoist control automatically causes the loaded bucket to accelerate, travel to the top, slow down and, if the top is in readiness, dump its load. Meanwhile the empty bucket comes down into the loading pit. The usual speeds are from 400 to 500 ft. per minute although some skip hoists are designed to give top speeds of 700 ft. per minute.

The loaded bucket going up is dumped by having its front wheels come over a knuckle or bend in the track while the hind wheels, having a wider gauge, continue up a straight extension of the slope. In this way the bucket tips over and discharges its load into a receiving hopper which is located directly above the rotating hopper and the little bell. As the charge is dumped, the coarser material will naturally roll to the far side of the little bell resulting in a partial segregation of the coarse and fine material. Such segregation if carried through to the furnace, would place the coarser material on one side and the finer material on the other and result in uneven heating. It is for this reason that the rotating top is used to distribute these segregations around the furnace.

Usually 8 or 10 skip loads are required to make up one complete charging cycle. Such a cycle is called a

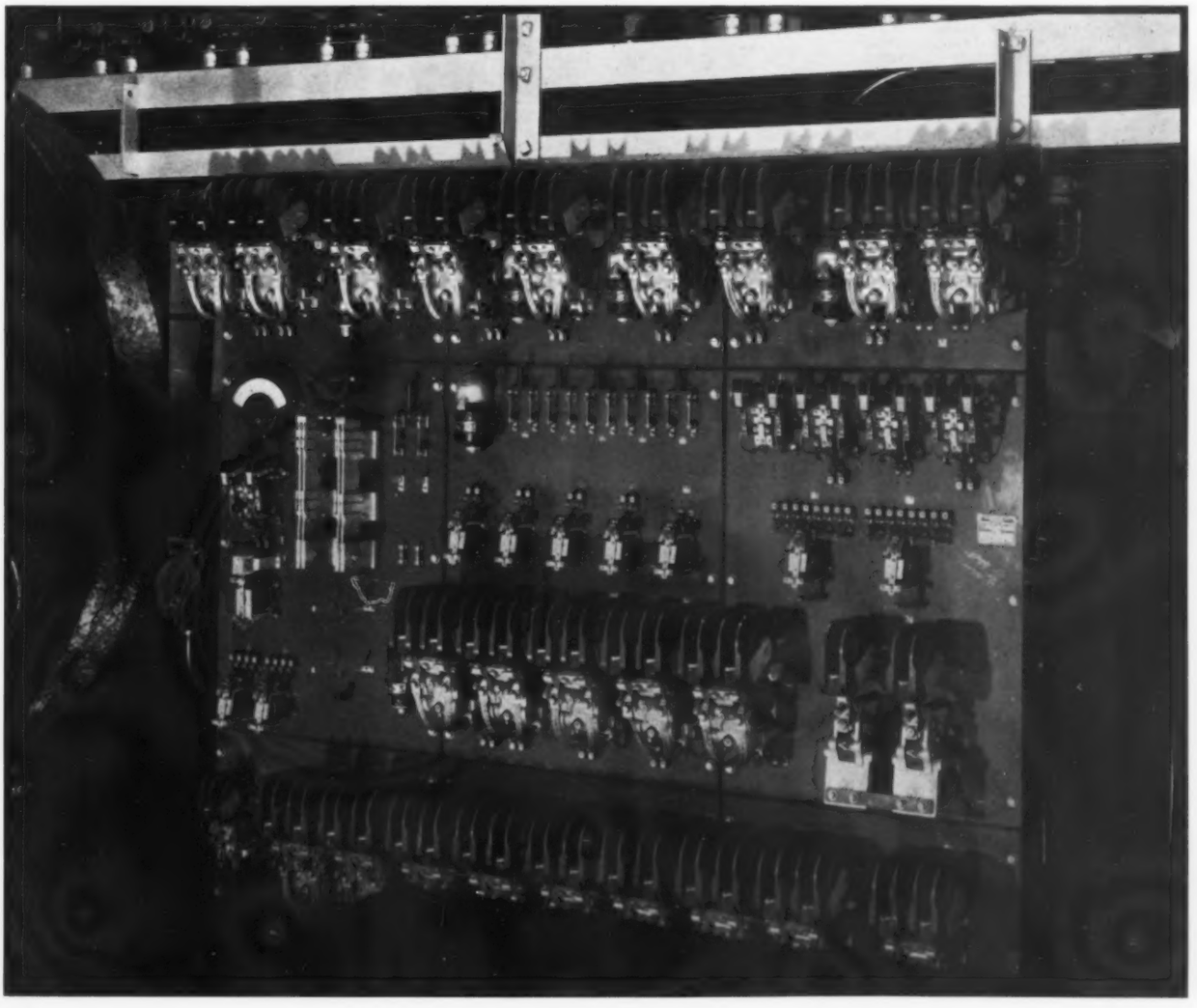


FIGURE 3—View of control board, which provides means for testing control functions independent of main circuits.

"round" and a typical round might include material in the following order: Coke, stone, ore, coke, coke, ore, ore, stone, coke, ore. During the dumping of one round the coarse material from the right hand skip will be thrown across to the left farther side of the small bell and the coarse from the left hand skip will be thrown across to the farther right hand side of the small bell. As the small bell lowers, this material will be dumped onto the large bell with corresponding distribution. This may continue throughout one complete round during which time the large bell may dump once or twice. During the next round, the small bell is caused to rotate after it receives the charge from the skip buckets and before dumping into the large bell. In this way it places the coarse and fine material in a different position with respect to the large bell and the furnace. The result is that after a number of rounds the coarse and fine materials are deposited around the furnace in the form of a spiral.

There are many theories as to how this should be carried out and many ideas have been tried regarding baffles and deflectors. What everyone is trying to accomplish, however, is a homogeneous or even distribution of the charge in the furnace, so that the gases will travel up through the burden uniformly to prevent excessive temperatures in any one portion. There are no two blast furnace superintendents who will agree entirely on the number of skip loads per position, the number of positions around the top and the order in which the different materials are dumped. It is therefore necessary that the control for a furnace top be possessed of exceeding versatility in order that different arrangements may be tried in an endeavor to obtain better furnace operating conditions. Many times the nature of the ore makes changes in the charging operation necessary. It is therefore usual to provide furnace top control which will allow easy adjustment of from one to ten skip loads in a position and six positions for the rotation of the furnace top. Certain installations have been made in which the number of positions have been adjustable from four to six.

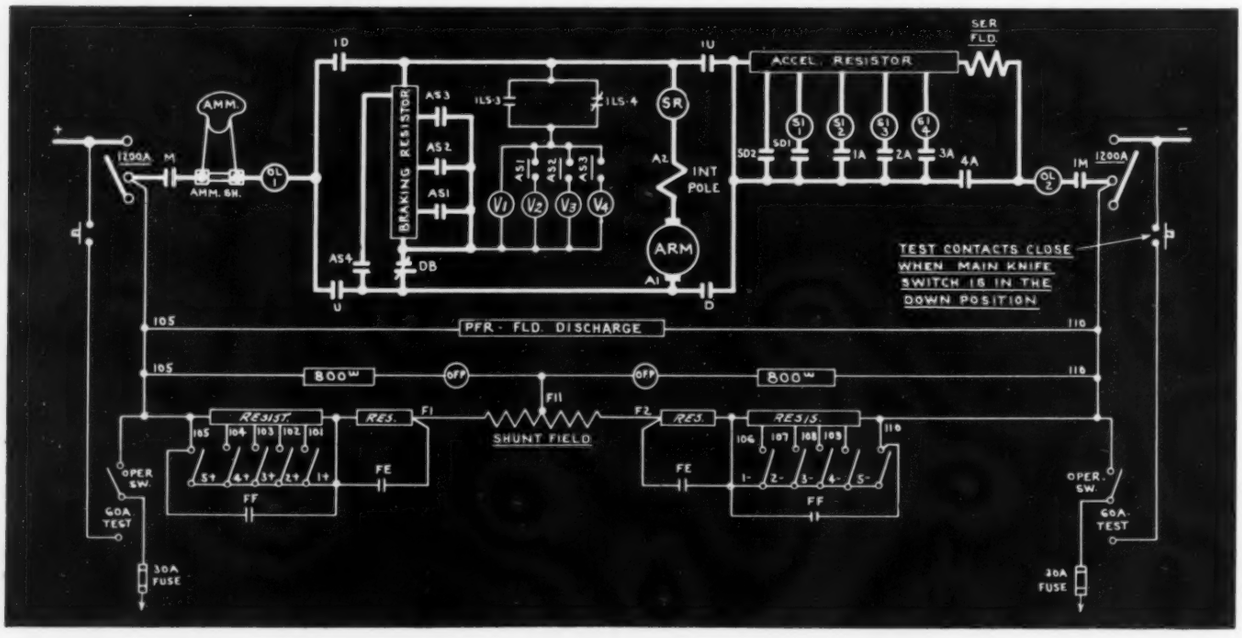
FIGURE 5—Characteristics of skip hoist motor through one cycle when operating at base speed of 485 rpm.

The sequence and interlocking of the rotating top with the small and large bell is as follows: A limit switch, closed by the skip hoist as the bucket nears the top, energizes a time relay which allows sufficient time for the bucket to reach the top and dump before it initiates the top rotation. Conversely electrical interlocks on the top controllers prevent the skip hoist from dumping if the small bell is rotating or is open.

Assuming that the skip bucket has dumped and the small bell has rotated satisfactorily, then the starting of the next skip load up will initiate a circuit to lower the small bell. The bell lowers about 2 ft. and has a slight delay in order to allow time for the charge to drop through the opening. It then closes and in so doing closes a control circuit which allows the dumping of the next skip load. Each time the small bell lowers, electrical circuits advance a notching device, or a motor operated face plate arm, one point, and when the accumulation of these points totals up to the number of skip loads for which the equipment is set, a circuit is then set up to lower the large bell.

This circuit initiating the lowering of the large bell does not start the large bell down immediately, but first hoists up the stock line recorder. This is a long rod extending down through a hole in the furnace top until the lower end rests on the burden. The rod is connected through a cable to a small hoisting drum. Geared to the drum is a face plate or other contacting

FIGURE 4—Simplified diagram of single motor rheostatic control skip hoist.



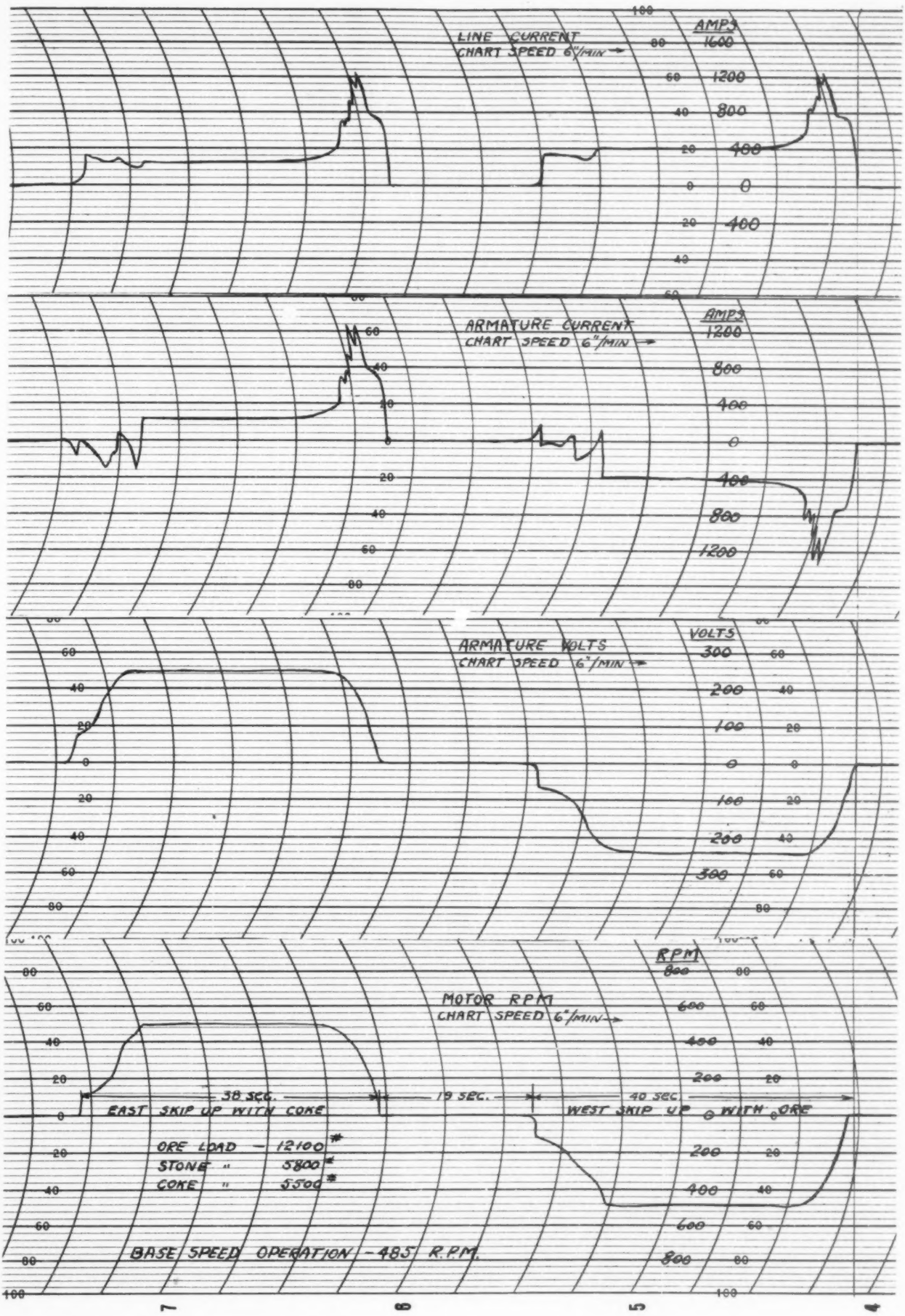
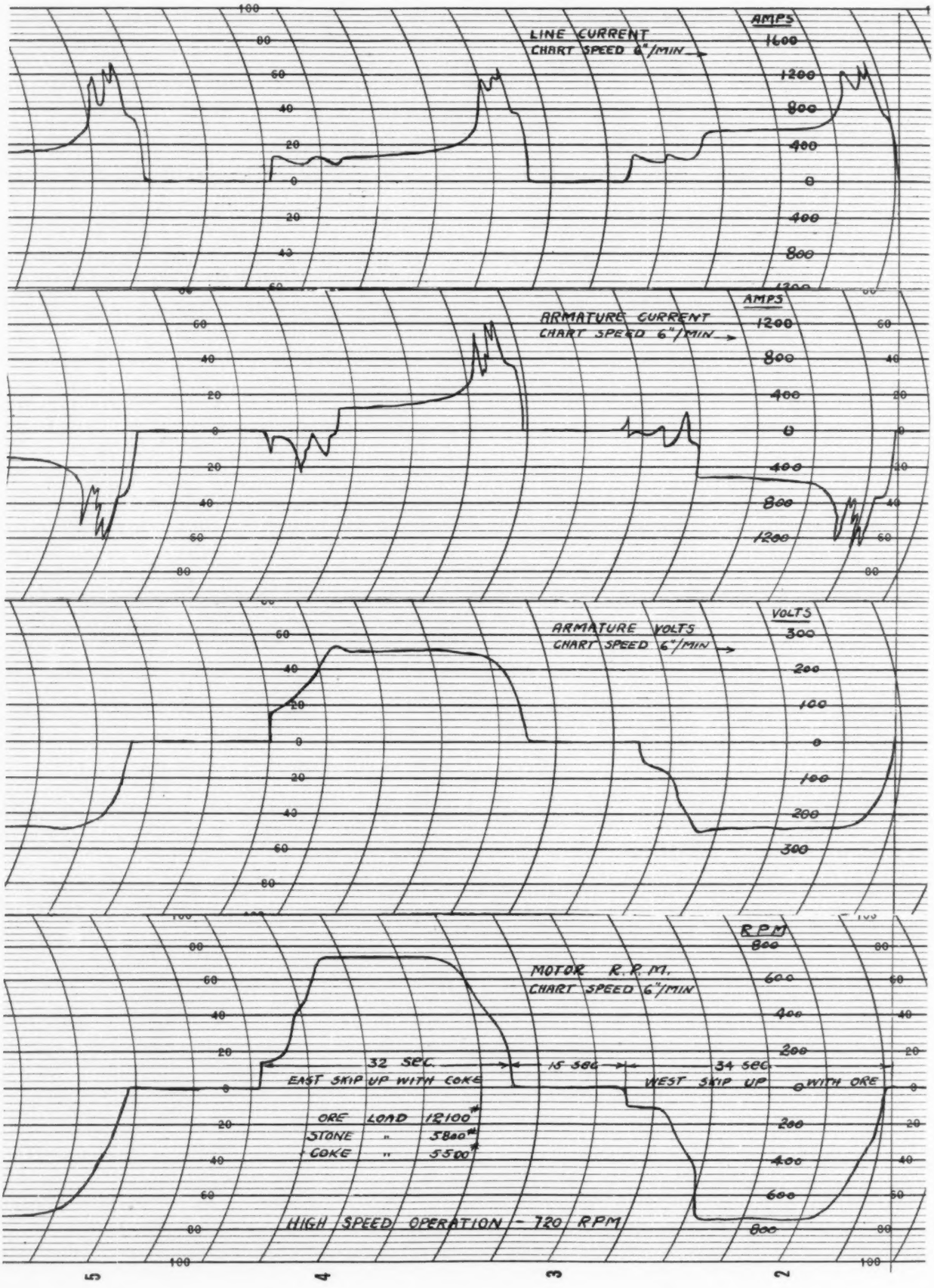

LINE CURRENT
CHART SPEED 6"/MIN →
AMPS
1600
1200
800
400
0
400
ARMATURE CURRENT
CHART SPEED 6"/MIN →
AMPS
1200
800
400
0
400
800
1200
ARMATURE VOLTS
CHART SPEED 6"/MIN →
VOLTS
300
200
100
0
100
200
300
MOTOR RPM
CHART SPEED 6"/MIN →
RPM
800
600
400
200
200
400
600
800
38 SEC.
19 SEC.
40 SEC.
EAST SKIP UP WITH COKE
WEST SKIP UP WITH ORE
ORE LOAD - 12100#
STONE " 5800#
COKE " 5500#
BASE SPEED OPERATION - 485 R.P.M.
7
6
5
4

FIGURE 6—Characteristics of same installation as in Figure 5, with motor field set for maximum speed of 720 rpm.



device for energizing indicating lights. As the rod follows the stock line down, the lights give a continuous indication of the level.

In certain designs of tops it is also necessary to equalize the gas pressure between the small and large bell before attempting to lower the large bell. This is especially true with equipment which does not provide definite operation of the large bell. The gas pressure beneath the large bell may hold it up as the cables are slacked off for lowering, and eventually, when the gas pressures do become more equal, the large bell and burden will drop to take up the slack in the cable with considerable shock to the furnace. In order to avoid this, the equalizer valve is opened to allow the gas pressure of the furnace to pass around into the compartment between the two bells. When this has been completed, circuits are set up by the operating mechanism of the gas equalizer, allowing the large bell to lower and drop its charge into the furnace. It, too, hesitates long enough for the material to drop clear and then closes. In closing, it sets up a circuit which closes the gas equalizer valve, lowers the test rod and permits succeeding operations of the small bell, Should either bell fail to close properly, limit switches prevent further dumping until the situation is cleared up.

Indicating lights operated by the various motions of the top rotate the small and large bells, and the position of the test rod give the scale car operator in the pit a visual indication of the position and operation of all parts and height of the burden in the furnace.

We have seen that three motions are involved in transferring the ore from the pit to the furnace, namely the skip hoist, the top rotation and the bell operators. The control for these motions could be built into one unit, yet we invariably find three separate controllers and often built by three different manufacturers. One reason for this diversity is the fact that many installations are being partly rebuilt or modernized. The old steam hoists and steam bell operators are being replaced by more modern electric drives, while the present top rotator, which is already electric, is being retained. In other installations, the steam skip hoists have been retained and made automatic by the installation of electrically operated valves. Another strong factor is the customer's preference for particular features, and then patent barriers make frequent detours necessary in order to satisfy these preferences.

Focusing our attention now on the skip hoist itself, we find many differences of opinion regarding the merits of the single motor rheostatic, the two motor series parallel, and the Ward-Leonard systems. The latter may be again divided into the motor-generator feeding one motor, the motor-generator feeding two motors, the motor with two generators feeding two motors, and two separate motor-generator sets feeding two motors. The arguments for and against each scheme are usually based on reliability, flexibility, maintenance first cost, power used and smoothness of operation. Several very fine papers* on the subject are to be found in the publications of this Association. It is not the writer's intention to repeat or refute these arguments, but to present data taken on a recent installation which indicates that the single motor with rheostatic control may be economically applied to hoists having greater ranges of speed than has formerly been accepted.

No. 3 furnace of the Republic Steel Corporation at Youngstown, Ohio, shown in Figure 1, was put into operation Oct. 5, 1938. A description of this furnace appeared in the Jan. 1939 issue of IRON AND STEEL ENGINEER. This furnace is equipped with a double skip using a 200 cu. ft. bucket operated by a single motor hoist with rheostatic control. Controls for the revolving distributor top and the hoist are mounted in the hoist house, and interlocked to make the installation fully automatic under the control of the scale car operator.

Figure 2 shows a view of the masters and indicating lights in the pit from which the hoisting operations are initiated. The vertical row of lights at the right give a continuous indication of the stock line in the furnace. The lamps are numbered consecutively from 4 ft. down to 14 ft. The second row from the right indicates the number of small bell operations from 1 to 10. The next row indicates the first or second cycle, whenever a round is broken up into two cycles, and also indicates the positions open or closed of the small and large bells. The group of lights at the upper left indicates the position at which the distributor top has stopped. To the extreme left is a scale and hand winch for manual testing of the stock line. Mounted on the pulpit rail where it may be conveniently reached from the scale car platform, is the hoist master.

A picture of the control panel is shown in Figure 3. This panel provides means for testing the control functions independent of the main circuits. The main knife switch is of the dead hinge type and, to insure that it is open before the control functions may be tested, the double pole double throw control knife switch must be thrown to the down position. The control power for testing is completed through the plunger type interlock which is depressed by the main switch in the down position.

The simplified diagram of the main and field circuits is shown in Figure 4. At standstill the full field contacts FF are closed but the field economy contacts FE are open, maintaining the shunt field at a slow value. The double coil open field protection relay OFP prevents operation with an open or grounded shunt field.

When the scale car operator throws his master to hoist No. 1 bucket, the field economy relays close, the spring closing dynamic braking contactor DB opens. Main contactors M and 1M and directional contactors U and 1U close to pass approximately full load current through the armature and series relay SR. This relay is set to operate on any current which will develop sufficient torque to hold the maximum load. The operation of the series relay energizes and releases the service brake, permitting the hoist to accelerate. As the service brake releases, an interlock on the brake energizes contactor SD1 to short out a portion of the accelerating resistor and energize the first time-current accelerating relay SI.

Time-current acceleration means that more acceler-

*Iron and Steel Engineer 1930-31 P. 227
*Iron and Steel Engineer May 1938
*Iron and Steel Engineer 1928-29 P. 477

ating time is allowed if the starting current is large, but unlike a current limit relay, the time-current acceleration relay will not lock out on large currents but will continue to force acceleration.

The time-current relays SI-1, SI-2, SI-3 and SI-4 control the closing of the accelerating contactors 1A, 2A, 3A and 4A. The latter shorts out the series field of the motor as well as the remaining portion of the accelerating resistors, so as to give the motor true shunt characteristics for good load speed regulation. An auxiliary contact on 4A de-energizes the full field contactor FF, allowing the motor to run at a higher speed according to the pre-setting of the field switches.

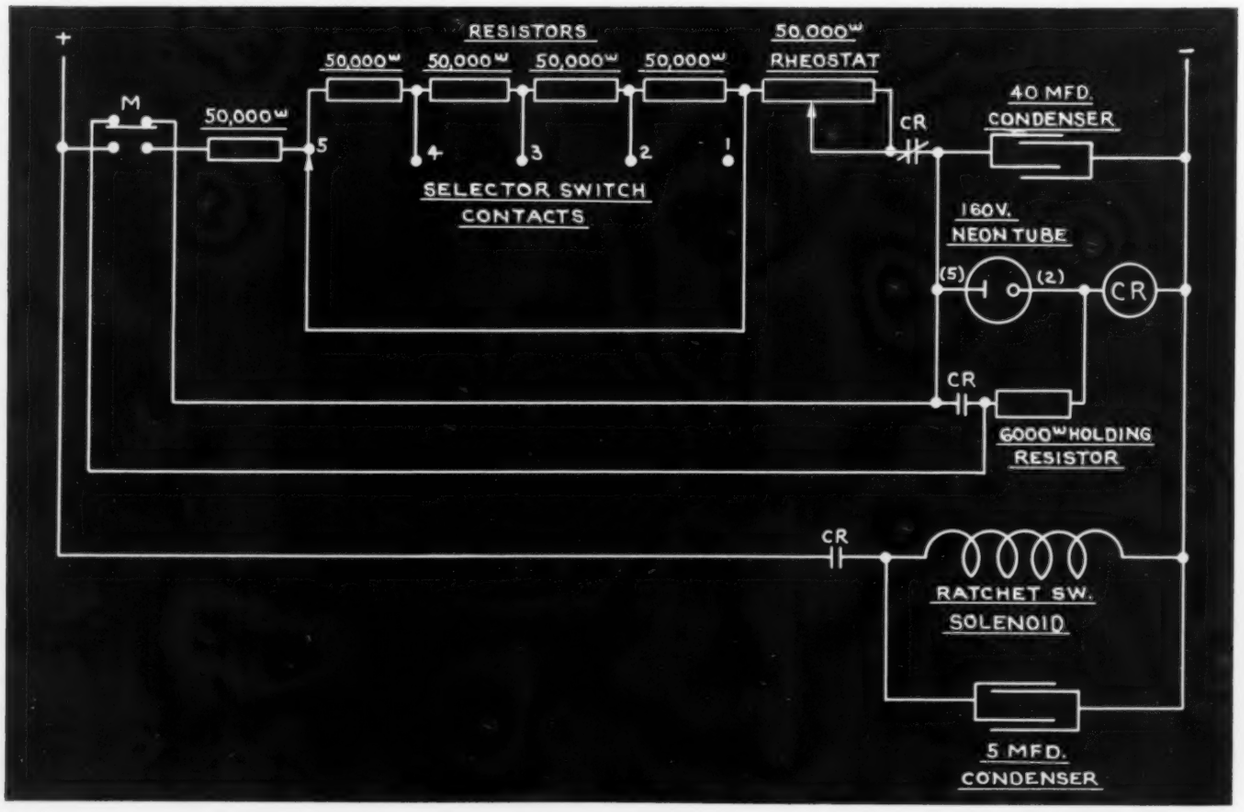
As the bucket approaches the top, a limit switch geared to the hoisting drum closes the contactor FF, applying full field for the first point of slow-down. Following this, a second limit switch opens, de-energizing the spring-closed dynamic braking contactor DB and the accelerating contactors 1A, 2A, 3A and 4A for the second point slow-down. Next, the limit switch 1LS-3 shown in Figure 7 closes to apply armature voltage to the relays V1, V2, V3, V4. These relays successively control the armature shunt contactors AS1, AS2, AS3 and AS4. They are arranged to close alternately V1, AS1, V2, AS2, V3, AS3 in a selective manner to determine the amount of dynamic braking required. For the heavier ore load relays V1 and possibly V2 will close. With a lighter stone load, relay V3 will also close. The lightest coke load will cause all relays to close.

As the armature shunt contactors close, they not only decrease the value of the shunt resistance but also introduce more series resistance by successfully opening the contactors SD1 and SD2. By this means, large amounts of power are not taken from the line during the slow-down period. Should the operation of relay V1, V2, V3 and V4 overshoot the mark, causing the armature speed and voltage to drop below the required value, the last operating relay will back off and restore the balance. This selective armature shunt provides practically constant speed of the hoist under loads varying from 5,000 lb. of coke to 18,000 lb. of ore, when the final limit switch opens. This allows close setting of the final limit switches so that the bucket may be tipped well over to dump the ore without striking the bumpers.

By means of field control switches, it is possible to vary the free running speed of the motor from 485-720 rpm. This in no way affects the final slow-down point since the motor quickly returns to its full field speed when the first point of slow-down is reached. Figure 5 shows the line current, the armature current, voltage across the armature and rpm. of the motor when operating over one complete travel at the base speed of 485 rpm. Figure 6 shows the same curves with the motor field set for the maximum speed of 720 rpm.

The usual objections quoted against single motor rheostatic control are rough acceleration and deceleration and abnormal waste of power. However, let us study the curves. It will be seen that the curve of armature voltage closely resembles the curve of speed as it would in a Ward-Leonard controlled hoist. With such a voltage applied to the armature, how can the

FIGURE 7—Simplified diagram of special timing control used on revolving top of a blast furnace.



motor be rough on the hoisting equipment? The writer can vouch that when standing beside the motor, the changes in speed appeared and sounded as smooth as those of variable voltage control.

Next, let us study the waste power. Graphic watt meters were not available when the curves were taken however, they would not have separated the waste power from the useful power, so we must approximate values of waste power by taking the product of waste current and voltage. The supply voltage was practically constant at 250 volts. Such waste power includes: —(1) approximately 800 amperes at 250 volts for one second or 200,000 watt-seconds while the brake is releasing; (2) approximately one-half the power input during acceleration is dissipated in resistors, amounting to 500,000 watt-seconds; (3) assuming that all power taken from the line during slow-down is wasted, there is another 560,000 watt-seconds. The total of these losses is 1,260,000 watt-seconds. This loss occurs once for every trip. The average skip hoist makes 45 trips an hour. If we average the losses over the complete time, we get 15,700 watts or the equivalent of a 21 hp. motor running continuously. It is this loss which should be compared with the fixed losses of the Ward-Leonard motor generator set.

Graphic curves showing the kw. input to a Ward-Leonard set on similar duty are given in a paper by Mr. E. Anderson*. The motor-generator set consisted of a 275 hp., 750 rpm., 3 phase, 25 cycle, 550 volt squirrel cage motor driving a 165 kw., 500 volt, 750 rpm. generator and a 12½ kw., 235 volt exciter. These curves show inputs at no load of 20 kw. or better, which is equivalent to a 27 hp. motor running continuously.

Another disadvantage charged against the single motor rheostatic hoist is that it does not allow sufficient range of speed. A safe dumping speed is considered to be 75 to 80 ft. per minute. By the means described above, there is no difficulty in obtaining definite slow speeds by armature shunt and series resistance of 25 per cent of base speed. A single motor, therefore, with 2 to 1 speed variation by field control can have a base speed of 320 ft. per min. and a top speed of 640 ft. per min. A normal operating speed of this motor would then be 400-500 ft. per min. with capacity for higher speed if required. A study of the curves shows that an increase in speed does not proportionately increase the amount of material handled, and so increasing the speed is not an alternate for a larger bucket and hoisting equipment.

Next let us take a trip up to the distributor top. This is not allowed when the furnace is in operation without the utmost precautions. So great are the hazards of gas that, when an inspection or adjustment is absolutely necessary, three men are required for the undertaking—one to do the work, one to stand within reach, while the third remains within view and possibly within reach of a telephone. The desirability of removing all unnecessary equipment from the top will be apparent. Older tops were equipped with motor, magnetic brakes and limit switches. The magnetic brakes were replaced by the use of dynamic braking controllers, and recently the limit switch has made its demise.

The Bethlehem Steel Company at Bethlehem, Pennsylvania, have replaced the limit switch on the rotating top with a timing device. The amount of rotation is a function in the time of travel. This is not just an ordinary time relay but is a special type, using an industrial type neon discharge tube and condenser for the time element. A simplified diagram of the timer is shown in Figure 7. The connections of the timer are such that the time interval is automatically increased by a decrease in voltage in order to compensate for variation

*Iron and Steel Engineer 1928-29 P. 477

FIGURE 8—Distributor top control may be set for a varied range of charging cycles.

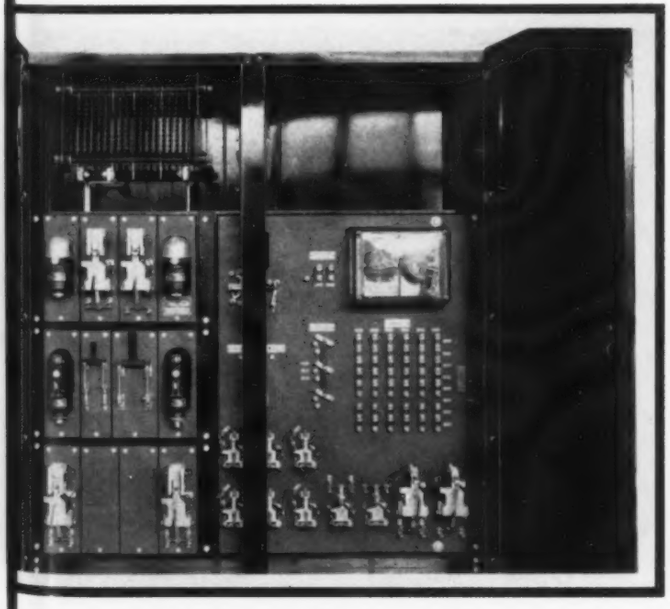
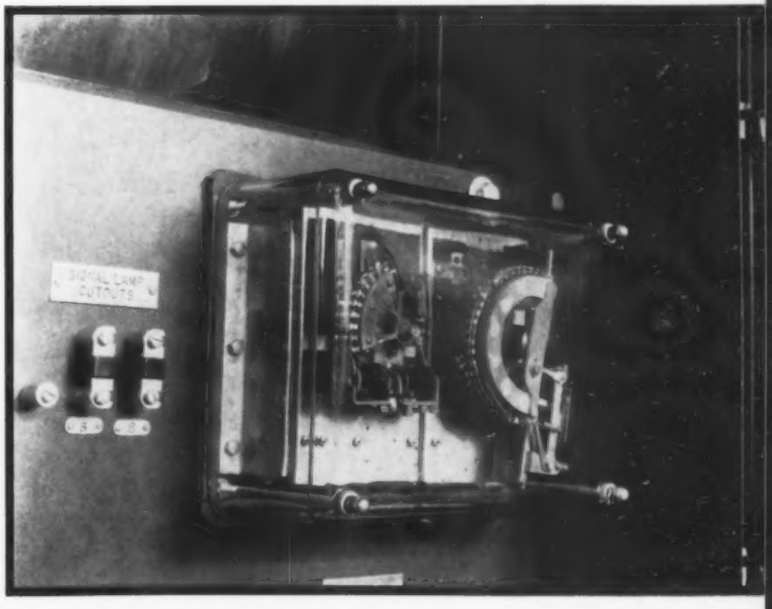


FIGURE 9—Close-up of rachet relay, used as notching device to count the number of distributor operations.



in motor speed. A compound wound motor is used with the series field cutout by the last accelerating contactor. This gives good starting torque with constant running speed and dynamic braking for stopping. The Bethlehem Steel Company reports that the accuracy of this timed travel is within 1 inch on a 6 ft. diameter gear.

Opinions differ considerably on the required accuracy of stopping the distributor top. It would not seem logical that a couple of degrees plus or minus in the rotation of the top would be vital in the dumping of a skip load of material, and if this variation may be permitted, the entire control may be placed in the hoist house requiring very little attention at the top.

A controller for a distributor top is shown in Figure 8. This consists of the magnetic controller with the notching device for counting the number of operations, means for adjusting the skip loads per position, the number of positions around the top, and the relays for operating the indicating lights. Many forms of notching devices are available ranging from the motor operated face plates and solenoid operated face plates, down to the telephone ratchet switches. A close up view of the ratchet relays with glass enclosing cover is shown in Figure 9. They are small compact units arranged for jack type mounting so that spares may be carried for quick replacement. Figure 10 shows the front and rear views of the relay units. The burden on these relays is extremely light and their reliability in service is equal to that of the American telephone. This particular panel provides for adjustment of from 1 to 8 skip loads per position by means of the replaceable links in the banks of terminals immediately below the ratchet switches. The number of positions at which the distributor will stop is adjustable from 4 to 6 by means of the three pole, three point selector to the left of the adjustable links.

Let us assume the controller is set for 6 skip loads per position and 6 positions, as is actually the condition shown in Figure 8. A limit switch geared to the skip hoist makes a contact as the loaded bucket nears the top, energizing a time relay on the distributor top controller. After a definite time, sufficient for allowing the bucket to dump, the top rotator motor starts and rotates the top 60 degrees. The cutout device such as that described above stops rotation and advances the notching device one point and lights indicating lamp No. 1. This operation continues up to 6 skip loads. Then circuits are set up so that, for the next 6 skip loads, the distributor top must rotate 120 degrees before the cutout device operates. Six skip loads are dumped in this position with indicating lamps lighting successively from 1 to 6. Connections are then established requiring 180 degree travel of the top to operate the cutout device. This operation continues for the 240 degree and 300 degree positions. For the 360 degree or beginning position, the top does not rotate. The notching device merely counts one for each skip load dumped. Interlocking contacts on the distributor top controller set up circuits which initiate the operation of the bell operators.

There are several forms of bell operators which include steam cylinders, electric crank motions, the horizontal screw with motor driven nut, etc. These are described in a paper entitled, "The Automatic Blast Furnace"*. A more recent development is the bell rig which uses a single reversing motor and two drums. One direction of rotation operates the little bell while the other direction operates the large bell. There is also a bell operator consisting of counterweighted air operated cylinders. Air for raising the cylinders is furnished from the cold blast pressure which supplies the stoves and furnace. The pressure is usually about 15 to 20 lbs. per square inch. Motor operated valves charge and discharge the cylinders to operate the bells. Hatchway limit switches operated by the bell cylinders provide the necessary interlocking and lamp indications. The control for the bell operators is beyond the scope of this paper.

*Iron and Steel Engineer 1925 P. 88.

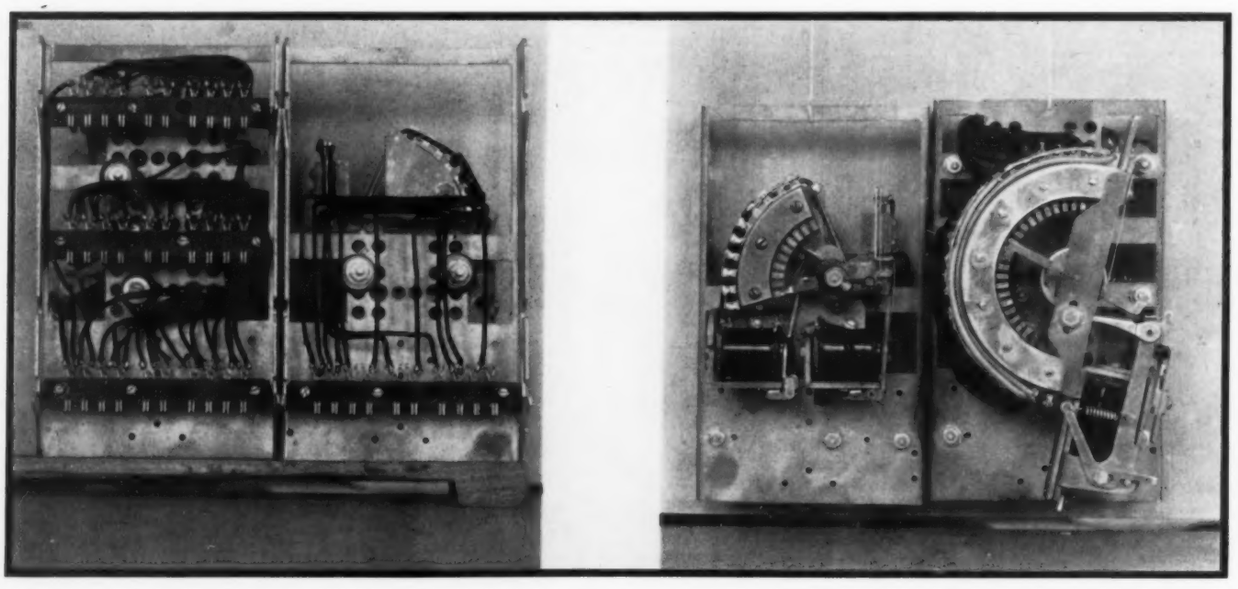


FIGURE 10—Back and front views of rachet relay of Figure 9, which is very reliable in operation.

Installing and Operating Grease LUBRICATING Systems

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Trabon Engineering Corporation

CLEVELAND, OHIO

Presented before A. I. & S. E. Pittsburgh District Section, February 28, 1939.

▲ THE subject of this paper might cover so many different phases of installation and operation of centralized grease systems that I will attempt to deal with the subject in a very broad light only. First, I would like to give a brief summary of the states of development of centralized lubricating equipment as it is applied to the industrial field as a whole.

Some of the older men in the lubricating equipment business can well remember the day when the steel industry began to realize that approximately 80 per cent of their maintenance cost was due to improper or lack of lubrication. It has been said that the realization of this fact was brought to their attention because of the advancement which has been made in bearing design and lubricants without any apparent improvement in the method of applying the lubricant.

With the early growth of the automotive industry, the public realized the need for proper application of lubricants in general. At that time, there was no practical method of lubricating the shackle bolts, steering knuckles and other bearings outside of the motor itself. The result from this situation was the first hand grease gun and grease fittings which appeared in about the year 1917. This pressure gun and grease fitting made it possible to put grease in the automotive bearings under pressure with the assurance that the grease was reaching the bearing. Another point in favor of this new method was the saving in grease; that is, they could deliver the grease directly to the bearing and it was not necessary to waste more than was actually used.

It was not long after this that the industrial field adopted the pressure gun and fitting for lubrication of production machinery. A few scattered uses of this equipment were made, however, it was not until the beginning of the golden era in 1923 when production started up tremendously, particularly in the automotive industry. Companies started production on 24-hour schedules and began to inquire if it were not possible to keep their machines running the full 24 hours without the need of shutdown for lubrication.

The lubricating equipment companies answer to this problem was the use of what is called the multiple tube system. This was nothing more than running a pipe or tube from each bearing down to a manifold or grouping place in some accessible place with grease fittings placed on the end of each tube. In this way, the lubricating man could force grease to every bearing on the machine no matter where it was located. It was at this time the flexible grease hose was first used to reach the moving bearings.

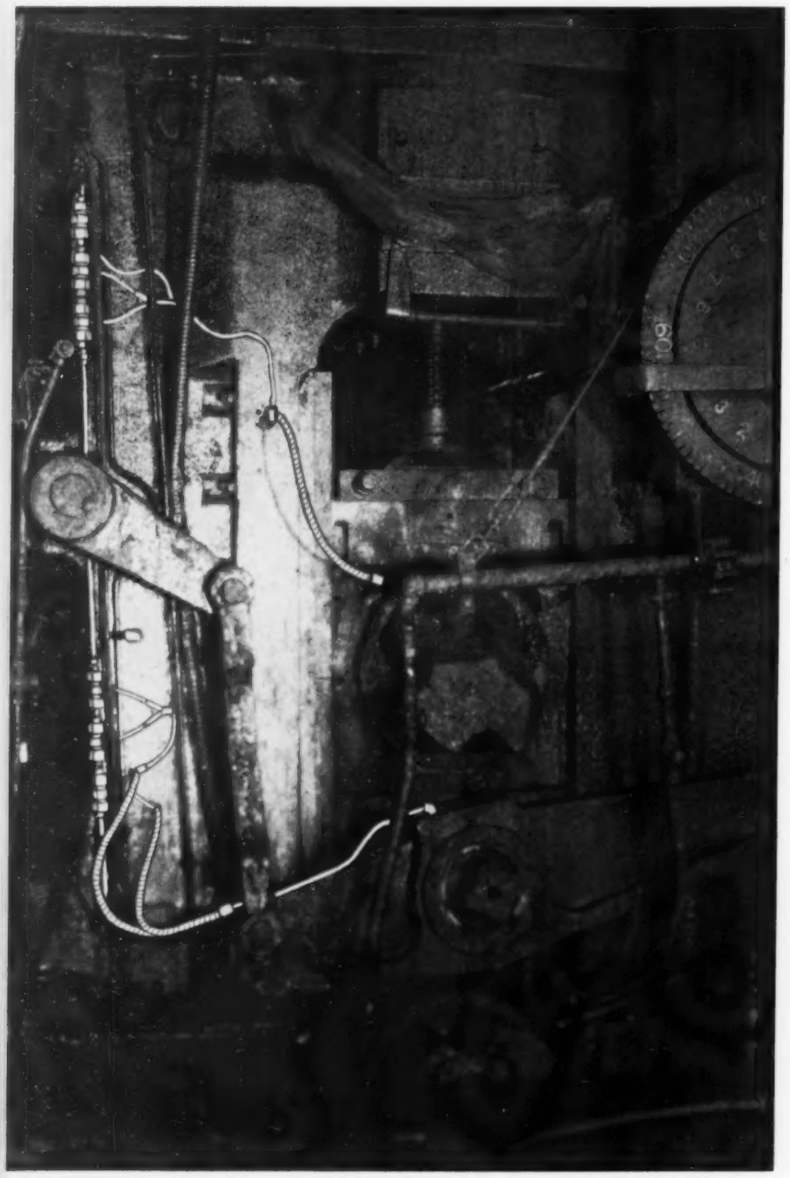
One of the largest automobile manufacturers seemed to take the lead, and, in 1924 asked the lubricating equipment men to make a complete survey of his plant in order to prevent the loss in operating time of the machines, or at least a part of it. This particular company spent $100,000.00 the first year in equipping both the new and old machines with the multiple tube systems for lubrication with a hand gun. This company later claimed that they could trace a saving of $30,000.00 the first year directly to better lubrication.

This method of applying grease, however, had its weak points. The operators were first instructed to force lubricant to the bearing until they could see it ooze from the end of the bearing. It was found that many of the bearings were so located that they were not visible to the man doing the greasing, which resulted in charts designating the required number of turns of the handle of the grease gun for each individual fitting. In order to assure sufficient lubricant, the quantity was usually enough to allow complete flushing and refilling of the bearing with grease. Picture, if you can, a panel containing 15 or 20 grease fittings and a man with a

hand gun starting with fitting No. 1, which, according to the chart, required so many turns of the gun handle, then on to fitting No. 2 with a different number of handle turns and so on to the last fitting. It was soon found that it required a mathematician to keep all numbers straight and to guard against possible omissions. In other words, the equipment worked properly if the human element was under complete control.

The next stage of development was to provide a means to measure the amount of lubricant that was being forced to the various bearings. One of the first steps was a measuring nozzle which could be attached to a hand operated gun; however, this brought about the problem of always delivering the same quantity to each bearing, regardless of the size of the bearing.

Ten years ago, lubrication equipment and experience was limited, making installations seem crude, although they are still operating today.



On certain types of mill equipment the demand was made that no grease should be allowed to drip or splash on to the product. The bearings must get enough lubricant to give 100 per cent lubrication, but on the other hand, no bearing on the machine should be overlubricated. On other types of mill equipment, it was considered to be good practice to allow lubricant to ooze out of the bearings over the machine in order to assure that all bearings were getting enough lubricant. This called for a measuring valve whereby specified quantities of lubricant would be delivered to each of the bearings.

While it is sometimes considered that the automotive industry was the first to demand centralized lubrication in its simplest form, we can say that the steel industry has shared equal rights with the automotive industry in the further demands for the centralized lubricating equipment as it is known today.

The earliest installations of centralized grease lubricating systems were installed with the thought of a reduction in maintenance costs uppermost in the minds of both the operators and the equipment men. Much to the surprise of some, in the early days it was found in a great many cases that the saving in power costs was a much larger factor than the reduction in maintenance. This reduction in power costs is one factor that has led to the assumption that grease lubricating equipment is a necessity on the mills of new type construction. With the revolutionary changes which have taken place in mill equipment within the past five to ten years, has come the demand for high speed and continuous operation. An operator or executive of any steel company would now consider it absolute folly to attempt to lubricate a continuous mill by any of the hand methods.

A few moments ago, I cited that the steel industry had shared equal rights with the automotive industry in the further demands for centralized lubricating equipment. While this is true, the trend in your industry has been along a different line than that pursued by the automotive or other industries. There has been a trend in the steel industry, especially in the past five or ten years, to attempt to lubricate more and more bearings from one central station. This has resulted in the development of pumping and control units designed especially for the steel industry. Other industries seem to prefer a separate lubricating system for each individual machine whether it be located in an isolated spot in their factory or whether it occupy its particular position in a production line consisting of many machines each designed to perform one or more operations. There are installations in steel mills where entirely too much equipment is being lubricated from one central pumping unit. However, there has been a tendency in your industry in recent years to provide an individual system for each individual machine or unit. Advantages of this plan are that the lubricating cycle can be changed to allow for varying conditions under which each unit may be operated, and, the added advantage of being able to compare one lubricant against another on two similar units operating under practically the same conditions.

Some of the more salient points which should be given consideration with an installation of a centralized grease lubricating system are as follows:

1. In the erection of a new mill, the lubricating system is usually one of the last things to be installed. When the installation crew arrives, they quite often find that the pipe fitters or the electricians have run pipes over the machine in such a manner that the lubricating lines must be run in most any available space remaining unused. For proper installation of any grease lubricating system, provision should be made for the lay-out of the grease lines before actual erection of the mill is started.

2. In a great many cases, the purchaser of a piece of mill machinery will order it from the manufacturer to be delivered with the grease lubricating system completely installed. There are three obstacles to be guarded against in this case. The first is—the tendency of some machine builder to omit some of the smaller or lighter duty bearings from the system which is sometimes done in order to keep their quoted price as low as possible. The second is—the tendency of some manufacturers to install their own lubricating systems when they are not familiar enough with its operation to do a competent piece of work as far as installing is concerned. I know that any of the lubricating equipment manufacturers would gladly send a man to inspect any new equipment delivered to your mill equipped with their lubricating system. Also, to thoroughly instruct your men in the operation of the lubricating system. The third obstacle which sometimes becomes a factor is the fact that it is necessary for the machine builder to change the design which will materially effect the number and sizes of bearings to be lubricated. Quite often these changes are not made known to the lubricating equipment manufacturers, therefore we find that when the lubricating system is delivered it will not fit, nor can it be laid out to efficiently lubricate the finished machine. Any one of the above three conditions is apt to result in the purchaser of the equipment being thoroughly dissatisfied with the lubricating system, when in reality the difficulty is beyond the control of the lubricating equipment manufacturer.

3. The next thing that comes to my mind in importance, is full information regarding the bearings on the machine to be lubricated. The information should list the types of bearings (anti-friction or plain), the sizes of the bearings, and special mention of any abnormal conditions under which they will operate.

Needless to say, any parts of the machine which require frequent change should be equipped with quick detachable couplings.

4. It is advisable that the lubricating men know the conditions under which the particular machine is to be operated. Let us consider the lubrication of a crane, for an example. The average individual thinks that a list of the bearings giving the number, size and type would be considered adequate information for figuring a lubricating system. There are cases, however, in which it would be an advantage to know under which conditions the crane is to operate. If the crane is to be located in some part of the mill that is exceedingly dirty, it may be an advantage to literally flood the bearings with a rather heavy lubricant in order to form seals at the ends of the bearings to exclude all dirt and dust. On the other hand, if this crane should be placed in operation in the finishing department, it would be imperative that the bearings never be over-lubricated in order to guard against drippings onto the finished or semi-finished product. I cite these two extreme cases because they might be under the jurisdiction of the same lubricating engineer. They may have a set rule that all cranes are to be lubricated at certain intervals which they would not want to change for the various departments. In this case, it would be good practice to deliver from two to three times as much lubricant to the bearings of the first crane, than to those of the last one mentioned. While ordinarily it would seem unnecessary to give all this information to the lubricating equipment men, it would, sometimes, be much to the advantage of all concerned.

5. One of the most important factors to be considered in the installation and operation of a centralized

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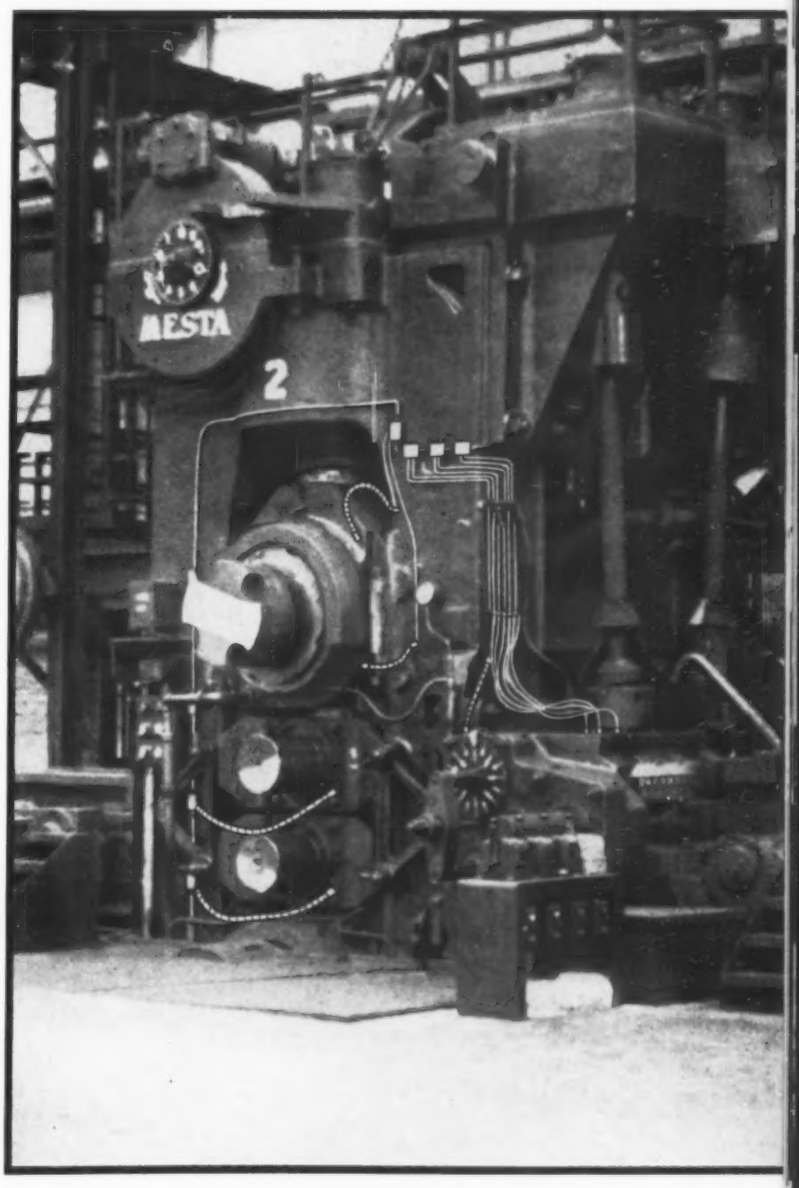
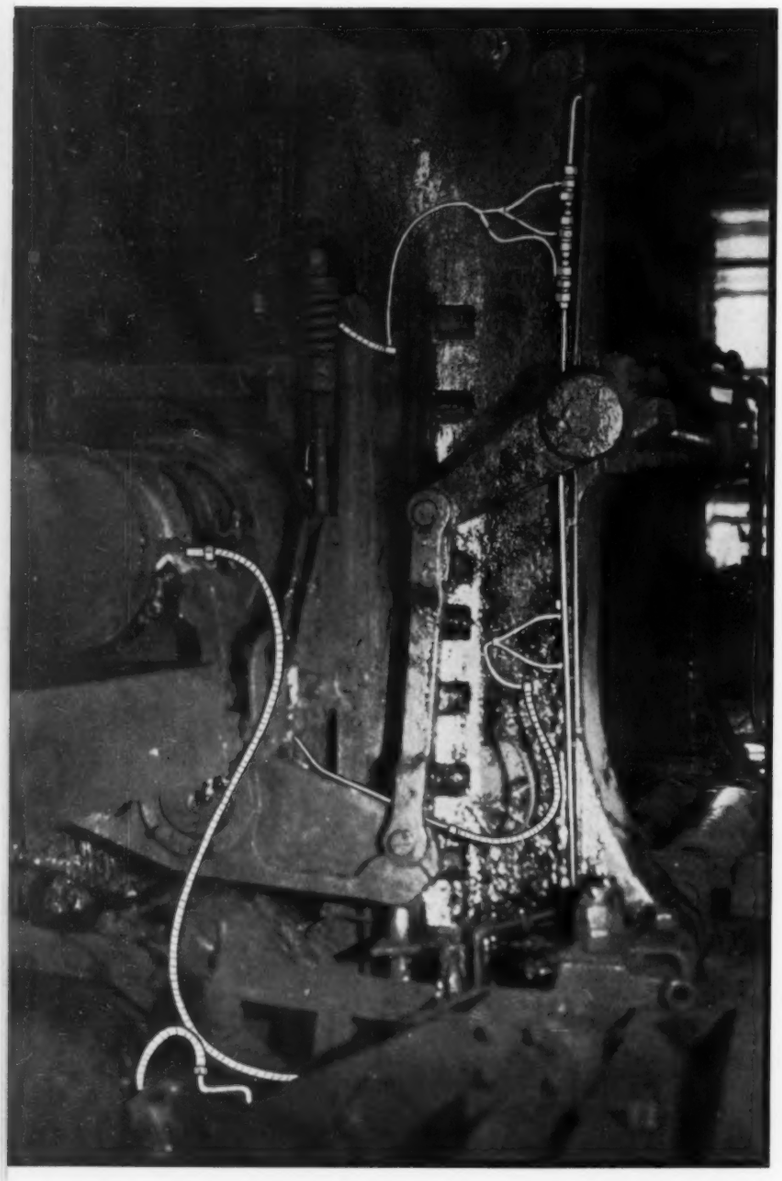
On modern mills, lubrication is applied to many more points without covering the equipment with excess grease.



lubricating system is cleanliness. By cleanliness I mean not only cleanliness in the original installation, but cleanliness in all of the surroundings during the operation of the system. Grease houses adequately heated and lighted in order to provide uniform conditions of temperatures and clean surroundings are considered a very good investment for the reduction of operating expenses. Grease houses in the average steel mill will do much to exclude mill dust which is found in the air of the mill building. Cleanliness can be further maintained by providing a filter through which all grease should be forced before entering any part of the system either during installation or in actual operation.

Early limitations of lubrication equipment sometimes required the use of two or three measuring valves on one bearing.



6. It is my strong recommendation that seamless tubing of either steel, copper, or some alloy, or a pickled cold drawn steel pipe be used instead of ordinary pipe on all the lines of a grease lubricating system. Ordinary pipe when subjected to intermittent pressures will shed a certain amount of scale which, when liberated from the inside of the pipe, will be carried into the bearings. Many a system has been condemned because of poor results, which are traced directly to dirt and scale in the lines of the system. A big advantage for the use of tubing, rather than pipe, on the installation of the average lubricating system is because the tubing can more readily be bent to conform to the contour of the machine, thereby reducing the number of joints or connections to a very minimum.

7. On machines which are to be lubricated by a hand or by a small automatic system, the location of the pumping unit should be given careful consideration. It should be located in a convenient place easily accessible and at the same time protected as much as possible from any possible damage.

8. Another condition to be considered in the installation is the condition under which the system is to operate. If there is to be no protection against extremely low temperatures, then the type of grease must first be definitely considered before laying out the lubricating system. It may be necessary to run a steam tracer line adjacent to the main grease line to assure operation in cold weather. It is not possible to apply heat promiscuously to any grease lubricating system because of the tendency of the grease to separate under high temperatures. This danger point has very wide limits, as with some greases it is possible to wrap a tracer line and a grease line with insulating material without danger of separation or boiling of the grease. Some other grades of grease, however, will bearly stand the temperature encountered with steam tracer line run in the open adjacent to the main grease line. In all cases, the type of grease to be used should be given the utmost consideration before laying out the system when it is necessary to combat the elements.

I believe this can be brought to your minds most vividly by experiences which, no doubt, you have all had. Who among us, at sometime or other, has not neglected to fill the transmissiom and differential of his car with a winter grade of lubricant in preparation for cold weather? Let us be hurrying to work some morning when it has suddenly turned to 10 degrees or less above zero. When the automobile is first started, it is almost impossible to shift gears, and I am sure all of you can picture this condition.

Now, assume that we have our mill grease line some 300 ft. or more in length, which may vary in size from ½ in. up to 2 in. in diameter and we attempt to operate the system on this same cold morning after the mill has been down. How long do you suppose it will require for the lubricant to become thoroughly pliable throughout the entire system? Your guess is just as good as mine.

I cite all of these conditions in an attempt to impress upon your minds the necessity of considering all factors before making an installation of a grease lubricating system regardless of whether the system is purchased directly by you steel men yourselves, or whether you have ordered it through a mill builder. There should

be very close consideration given to all of the points mentioned previously and very close cooperation given in order to provide a system which will operate satisfactorily and continue to do so under the varying conditions.

OPERATION

We have noticed a tendency in recent years toward the employing of a higher grade of men for the care and operation of grease lubricating systems. In this respect, allow me to express a word of appreciation to the steel industry. As steel has found that the newer mill equipment requires more highly trained men for its successful operation, so the lubricating equipment installed on these new mills has naturally received better attention. It might also be well to bear in mind that even the highest trained man needs more than a sledge hammer and a 24 in. wrench to properly maintain a centralized grease lubricating system. For this work, he needs only a few simple tools which the management should readily provide.

Some of the mills that have purchased centralized grease equipment have installed very definite programs for the inspection and care of the systems. As a comparison, kindly notice in your own mill the inspection given to a circulating oil system and that given your grease system. You may visit the most untidy of mills and you will invariably find that the circulating oil system is given very close attention and that this one of the cleanest parts of the mill. We people who are responsible for the grease system feel that better results might be obtained if only a fraction of the attention were given to the grease systems that is given the oil systems.

The mill equipment itself, should be maintained in such condition that all parts of the machine are visible and easily accessible for thorough inspection by the man in charge of grease lubrication. If the machine is so surrounded by trash that it cannot be readily approached or climbed over, chances are, 99 to one, that this machine will be overlooked during inspection. We have seen grease houses so filled with trash that the operator could hardly expect the systems to be kept in first class condition.

For continued operation of any mill, we feel it is absolutely necessary to have a well regulated program whereby the reservoirs of all systems should be filled periodically. If such a program is established, there should never be an excuse for a reservoir becoming entirely empty. I wish to call your attention to the fact that most any of the pumps used on centralized grease systems will readily pump air if there is nothing better available to be pumped. Air has proven to be a very poor lubricant. The speaker can readily recall having received a very urgent demand for service to a recently installed grease lubricating system. After traveling 300 miles, it was discovered that the grease reservoir was empty. I mention this purely to emphasize the point of the lack of a well regulated program for care of the operation of grease lubricating system.

The manufacturers of grease lubricating equipment have often been called upon to give definite recommendations as to the amount of lubricant necessary to assure satisfactory operation of the mill machinery. It is an impossibility for us to give any hard and fast rule covering this point. The principal reason for this is because of the wide variation in results which can be obtained from different lubricants.

The companies manufacturing greases should be congratulated on the tremendous strides which they have made in the development of higher grade lubricants, especially during the last ten years. One mill operator may pay from 30 to 50 per cent more for the grease he uses than his neighbor, and thereby he might easily reduce the quantity consumed to one-half. We have seen actual cases where this has been done by paying an increase of only 20 per cent. Your lubricating equip-

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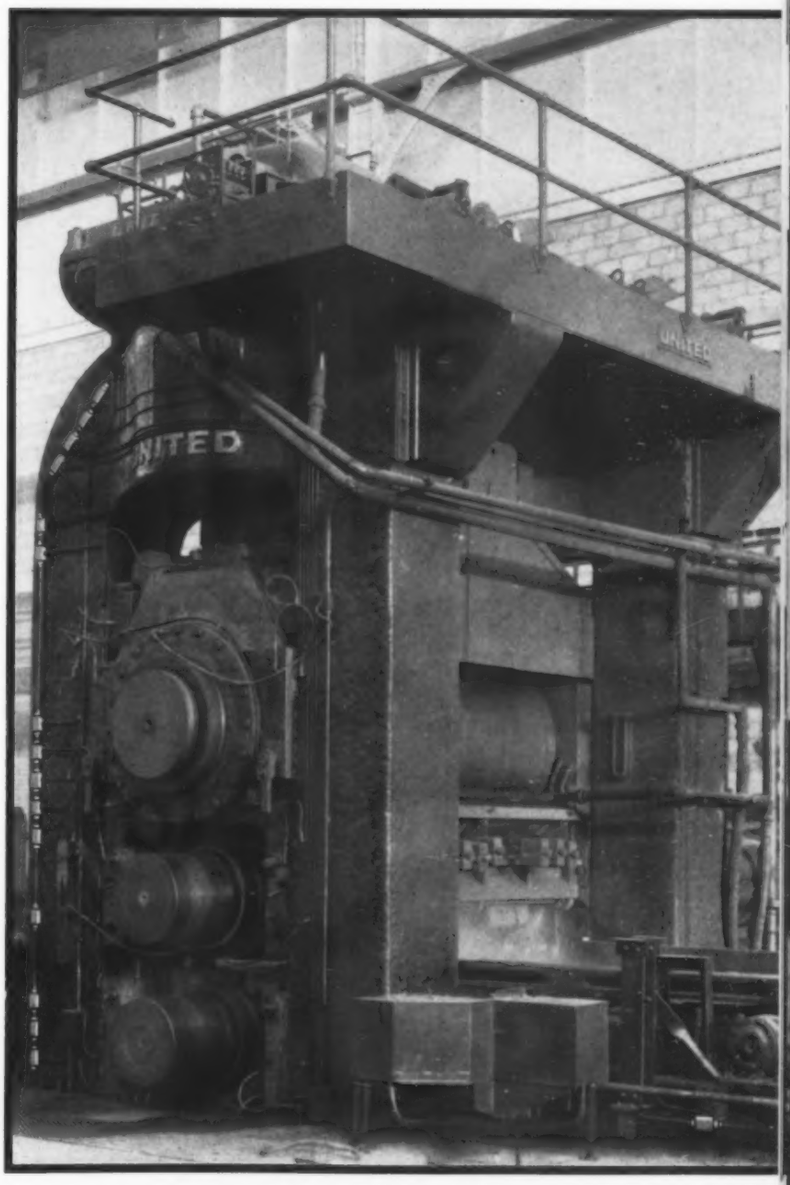
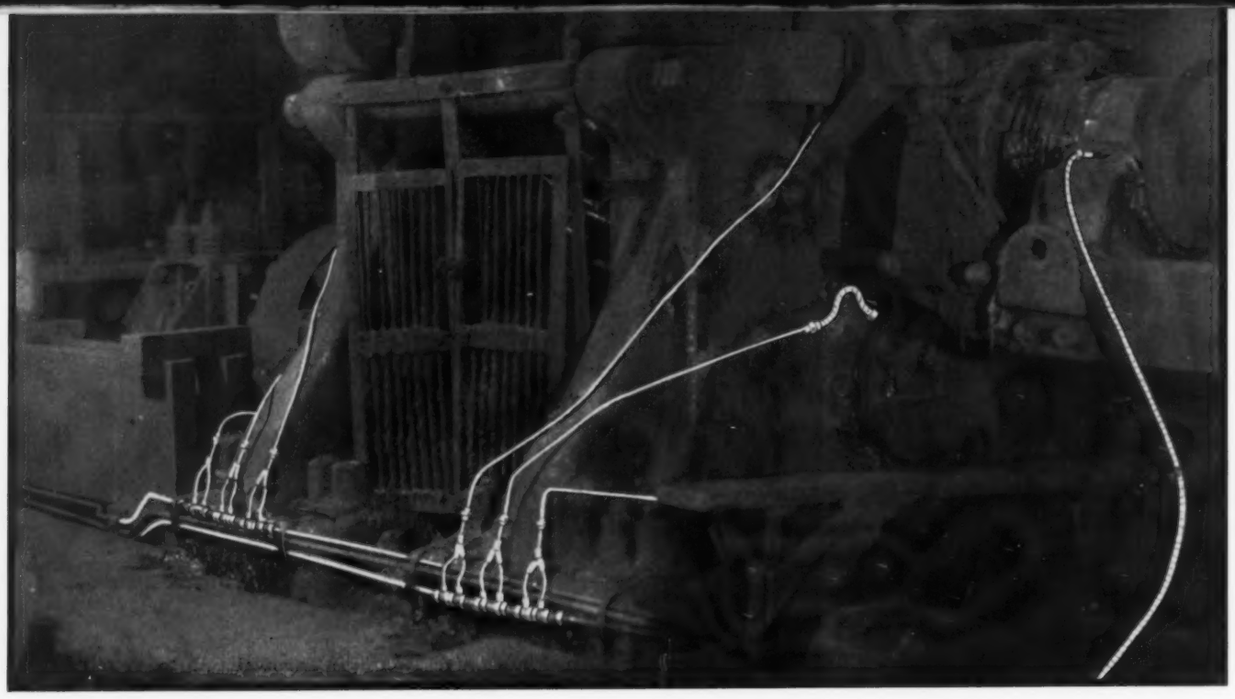
The wide range of equipment available today eliminates connecting two or more valves to one point of lubrication.





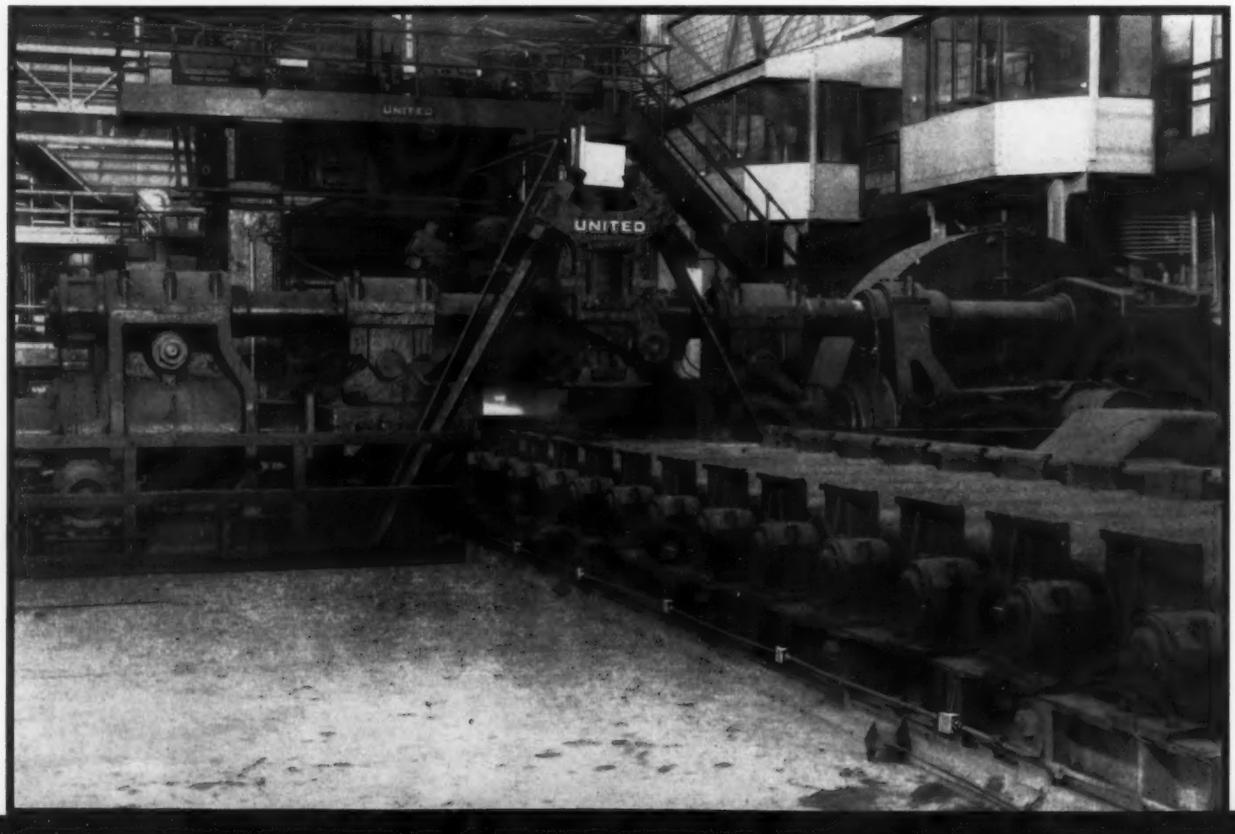
Type of bearings and impractical points of application of lubricant led to considerable waste of grease in older systems.

ment manufacturer can deliver lubricant to your bearings in order to provide a required thickness of film, however he cannot tell you exactly how often that film should be replenished.

Another reason for it being impossible to give definite information is because of the conflicting opinions of the various mill superintendents. One operator will want to see his mill equipment dripping with grease—giving the argument that an excess of lubricant is better than not enough. The next mill superintendent is apt to insist that there can be no excess lubricant on the outside of the mill machinery.

There is one point in this paper which I would like to stress the second time and that is the word cleanliness. This is one of the most important points in this entire paper. I recall a story once told by a lubricating engineer in the steel industry. It seems that he had an isolated oil system lubricating certain points on a mill which continually gave him trouble. He had tried numerous types of oils and varied the method of application a great many times, however, he had failed to thoroughly lick this problem. One day when he was in the mill he chanced to see a ray of sunshine coming through the roof of the building. It did not occur to him that there was dust in the air in that mill and not until he had seen the ray of sunshine which was heavily loaded with metallic particles did he realize the cause

Lubricating systems are installed in an efficient, symmetrical manner on modern mill equipment, giving greater operating economies.



of his troubles. Naturally, his next step was to make his lubricating system entirely dust-proof and his problem of lubrication of those bearings was ended.

CONCLUSIONS

As stated earlier in this paper, the first installation of centralized grease systems were made with the thought of savings in maintenance costs. I cited a case in which one large company had saved 30 per cent of their investment during the first year. The steel industry is a little more exact than some of the other industries in the breakdown of manufacturing costs. It is to the steel industry that we owe the earliest records of saving in power due to centralized grease systems. In some cases, these savings have been tremendous. A third saving in operating costs which should rightfully be mentioned here is the saving in lubricant, itself. Along with the method of application of lubricants which has prevented wastage, has been the improvement in the grade of lubricant itself. The combination of these two for which we take part credit as an industry has been very marked.

I do not need to cite percentages in the saving in power, maintenance or lubricants, because the industry as a whole is more or less familiar with these figures. If I were to cite conditions, naturally, I would want to give those showing the largest percentages. If I were to be truthful and give our best showings, there probably would be 50 per cent of the men here tonight who would not believe anything I had stated in this paper. All joking aside, there is a great deal of truth in that last statement. Some of the savings due directly to the centralized grease systems have been tremendous. However, in those most marked cases, I might say that it has been in mills where the lubrication has been under the direct supervision of a very competent engineer.

DISCUSSION

PRESENTED BY

T. R. MOXLEY, General Master Mechanic, Wheeling Steel Corporation, Steubenville, Ohio.

A. J. JENNINGS, General Sales Manager, Farval Corporation, Cleveland, Ohio.

R. M. GORDON, Manager, Gordon Lubricators Division, Blaw-Knox Company, Pittsburgh, Pennsylvania.

L. W. DEUTSCH, Trabon Engineering Corporation, Cleveland, Ohio.

T. R. MOXLEY: I have listened with a great deal of pleasure to the paper of Mr. Deutsch, and those of us to whom are entrusted the application and lubrication of mills, can appreciate all he has told us. There is no doubt that our mills without automatic lubrication equipment today, particularly strip mills, could not be lubricated properly.

The one thing I want to speak of this evening is that either the manufacturers of automatic lubricating systems, the manufacturers of the mill equipment itself or we fellows who are trying to keep the oil in the bearings will have to devise a grease seal that will hold it in there. When we speak of automatic lubricating systems, we immediately think of a heavy grease. Really the only valuable part of that lubricant is the oil that is in it. The compound contained in this lubricant for the purpose of holding the oil in saturation, in my opinion, doesn't do the bearing any good. So for that reason, we master mechanics would like to see someone design an efficient seal; and we are making efforts along that line ourselves and have been more or less successful in holding the grease in the bearing after it had been applied. I think most of you will agree that as much grease gets out of the bearing without having done it any good as is pumped into it.

We recently installed a lubricating system in our cold strip mill and the manufacturer of that lubricating system told me a centrifuge was not needed because we were putting in a dual communicating system. We could use the old method we used 25 years ago of dehydrating the oil from lubricating system by heating it up and cooling it off. There are a number of lubricants and oils that won't do. We tried a 2200 viscosity 16-20. They won't guarantee it after it is out of the factory. It behooves us to keep this water out. We started this system up and before we had operated for three weeks this 16-20 at 130 degrees, at which it was not supposed to emulsify, reached the point where it looked like molasses and we had to discontinue its use. We got a centrifuge and discontinued this oil and 50 per cent went down the sewer.

One of the worst things is the water, particularly on the bottom back-up and bottom work roll bearings, and until we get, as I said, adequate seals to keep this water out and to hold the oil in, an excessive amount of lubricant will be wasted. We went to work after our sad experience of losing 3000 gallons in this system to perfect a seal to hold oil in and keep water out, and whereas the system contents averaged from 10 to 15 per cent water, today we operate continuously year in and year out with less than .5 per cent water. The trouble was all in the oil seal. We made an oil seal with a cylindrical ring made of bronze in three sections using step cut joints as in piston rings, ground to a close fit, and then machined a groove outside the oil ring in which we inserted a stiff spring, and where this oil seal ring was permitted to revolve with the roll (and of course this

oil ring revolved in a channel in the bearing), we put a fit in the channel of this bearing of .003″. That caused the failure of that ring, even with a thrust bearing which is supposed to hold the back-up roll in a stationary position; nevertheless that roll will oscillate possibly not more than .003 inch, but just enough to wear that seal ring to where it will permit water to get in and let grease out. It was useless to increase the pressure as it would still let the oil get out. In re-designing this three-piece ring we made it stationary in the chuck, and having it made in three pieces, that allowed joints to be ground to a perfect fit. With the spring on the outside diameter there is enough pressure to bring this ring in to the neck as the ring wears. Being stationary when oscillation takes place it will not be up in the bearing channel but inside of the ring. Since that installation we have not had any water in the bearing and we run one centrifuge two or three times a week for one hour.

As Mr. Deutsch says, there are a great many people who like to see a bearing flooded, believing as long as it is flooded with grease it has plenty of lubrication in it. That is one thing that I try to fight with all the force that I have by contending that the grease that goes out of the bearing has not done the bearing any good.

At Steubenville we operate one of the pioneer hot strip mills. We have a number of tables that are operating with line shafts and bevel gears to drive the table rollers. We find that the action of the bevel gears on the table roll will act more or less in the nature of an impeller in a centrifugal pump, or as a paddle wheel. The men who are responsible for applying the oil to this gear case will get too much in it, then, due to the rotary action, oil will be forced to one end of the gear case and you will find it on the floor. What we are doing at the present time is to install baffle plates so that each gear will be contained between two baffle plates where the oil cannot get from one gear to another. Consequently, we overcome to a great extent the loss of lubricant being pumped out of the other end of the gear case. In my opinion, if it were possible to avoid leakage, there would not be any grease used in our mill, because, after all, it is the oil that does the lubricating and if you can put oil in a bearing and keep it there you do not need the heavy grease. We have proven that beyond the possibility of doubt where we have provided means of keeping water out and oil in.

As Mr. Deutsch says, in the operation of these systems we cannot be too particular in the application of the pipe lines from the system headers to the valves. On all the automatic systems that we have installed in our plant we have taken the precaution to pickle these pipes and have made positively sure by running a ram through to get the loose scale off, and I agree with him that where tubing can be used that is the proper thing to use. We have no trouble in getting grease into the bearings; our problem is keeping it there after getting it in.

As I said before, at Steubenville we do not have all the latest improvements that the newer mills have today. We have line shafts from finishing stands to coilers. In principle that is just about the same as if you dipped them in the Ohio River, because we have water sprays from mill to coiler to get the metallurgical effect and these tables are covered with water anywhere from two to three inches deep when strip is running through it. To effect proper lubrication under those circumstances, you can readily see what is necessary, and what we are striving to do—to keep water out and grease in.

A. J. JENNINGS: I feel that perhaps in stressing the importance and necessity of evaluating in advance the type of bearings, the kind of grease to be used, the actual operating conditions and all the other elements which are factors, Mr. Deutsch may have made some of you a little hesitant about putting in any lubricating system. Some of you might feel that you had to begin by selecting a grease that would work in the device regardless of whether such a lubricant would be suitable for the bearings or not.

After all, you must first select a lubricant that is suitable for the bearings and if the lubricating equipment manufacturer knows in advance the type of lubricant to be used, he can and will lay out his system to successfully meet those conditions.

R. M. GORDON: I would like to comment on Mr. Moxley's discussion. As most of you know, I am interested in grease systems. I believe there are just as many arguments in favor of grease lubrication in its proper place, as for oil lubrication, and I am sure that most of the grease manufacturers will support my contention that not all of the good in a grease is in the oil.

Mechanical oil lubricators have been in use for twenty or thirty years, and it is my opinion that a large part of the equipment now lubricated with these devices could better be served by a properly designed and applied grease system. In my opinion, the oil system was adopted in many of these cases, because of the fact that there were no available grease systems, and from an operating viewpoint, it is certain that a positive means of applying oil to bearings is certainly better than a hit and miss method of grease application, even though the bearings could better be served by grease. Unless the design and speed of the bearing is such that oil lubrication is called for, that is to say, precision bearing with a rubbing speed of 250 to 300 feet per minute or greater, I think you will find that grease of the proper specifications would provide better lubrication.

L. W. DEUTSCH: Mr. Moxley's remarks regarding the trouble experienced with oil seals primarily covered their application to a circulating oil system. We, with the grease systems, encounter the same difficulty in keeping water out of anti-friction bearings. This condition is sometimes serious because the water remains in the bearing without any chance of it being carried away. We have found that great improvements have been made in recent years in the oil seals that are used.

Mr. Moxley's remarks, that the valuable part of any lubricant is the oil that is contained in it, we believe, is further emphasized by the fact that most of the extreme pressure lubricants used today in the steel industry are of a much lighter consistency than the greases used before the advent of centralized lubricating equipment.

Mr. Jennings' remarks further emphasize the value of complete information regarding the size and type of bearings as well as other conditions to properly engineer a lubricating system.

REHABILITATION of a Battery of Vertical Flue COKE OVENS

▲ THE No. 2 battery of ovens at Woodward, Alabama, originally consisted of eighty ovens with an average width of 19¾ in., length of 39 ft. 6 in. and a capacity of about 12 tons of coal per oven. The battery was built in 1913 and operated until 1925. At that time one-half of the battery (the first forty ovens) was rebuilt completely from the mat up, including new buckstays, collecting main, all oven steel-work and operating machinery.

In order to permit the operation of the north half of the battery, which is nearer the stack, during the rebuilding of the other half, two ovens, Nos 41 and 42, were filled with brick and converted into a division wall between the two halves of the battery.

After the first 40 ovens, which we will hereafter refer to as battery 2-A, had been rebuilt and operated for some time, it was finally decided to shut down the other

Presented March 2, 1939, before the Eastern States Blast Furnace and Coke Oven Association, at Pittsburgh, Pennsylvania.

By E. R. MERRILL

Superintendent, Coke Plant

WOODWARD IRON COMPANY

WOODWARD, ALABAMA

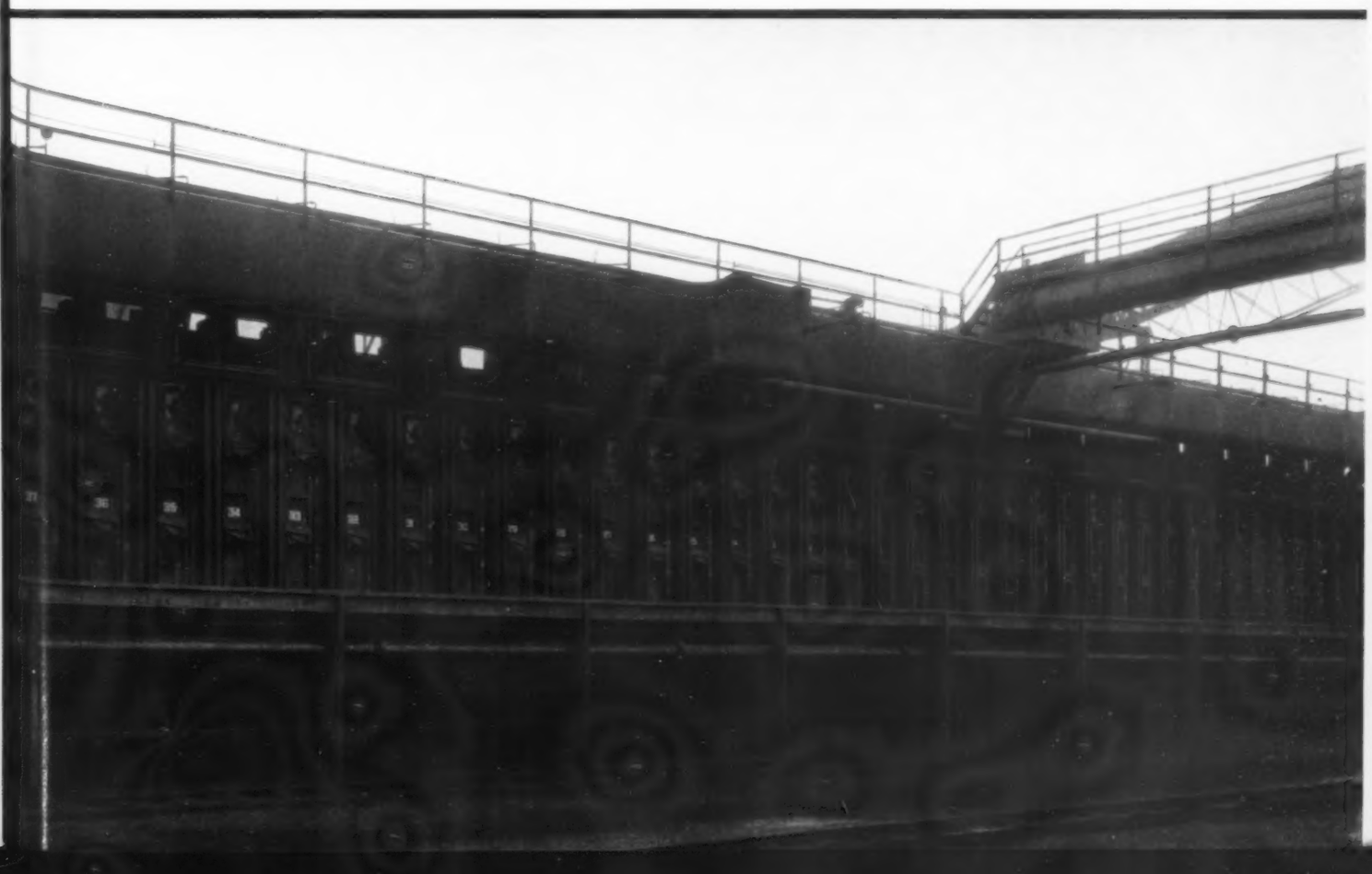


FIGURE 1—View from pusher side of battery after completion of rehabilitation work.

half, or battery 2-B, and so in 1931 operation of 2-B was discontinued due to the poor condition of the unit as a whole and the marked decrease in coke requirements at that particular time. Consequently the coke was pushed out but the battery was maintained at a temperature high enough for immediate charging until early in 1934. Then it was decided to discontinue heating for two reasons. First, there was no indication of need for the battery in the near future and second, the battery was considered by everyone concerned to be in such bad condition that rebuilding, or at least a repair job of considerable magnitude, was absolutely necessary before it could be expected to produce its share of coke.

It is unfortunate that no photographs of the battery were taken before the repair work was begun, so that one could, by comparison with the pictures made after repairs, more readily appreciate the extent to which the battery was improved by the work done. The collecting main and crossover main were rusted so much that large holes were seen in many places. The buckstays were warped to such a degree that, in many instances, it was impossible for the door machines to pass, and in several cases it was very difficult to remove the doors. The warping of buckstays has caused them to pull away from the jambs, and this space had subsequently been filled with 9 in. brick to furnish some kind of support for them. The thickness of this added brickwork was as much as twelve inches in some cases.

When the gas was cut off the flues in 1934 no attempt was made to cool the battery slowly, as has been done in some coke plants, and no protection was provided against the elements. The battery was allowed to stand in that condition until August of 1937. Since nothing was done during this period of approximately three years to protect the battery from the weather, instances occurred where charging hole covers and in-

TABULATION OF DATA FOR FIGURE 2.

Historical Data

(A) Ovens were constructed in 1913.
(B) Ovens were in operation from 1913 to 1931.
(C) Ovens were taken out of operation and allowed to stand in cold state from 1934 to fall of 1937.
(D) Ovens were repaired and warming-up period started Oct. 15, 1937 and completed Dec. 9, 1937.
(E) Repaired ovens were put into operation Dec. 9, 1937.

Summary of Expansion Data

Computed from the maximum values:

(A) Average total horizontal expansion for new walls = $\frac{3}{4}$ in.

(B) Average unit horizontal expansion for new walls = $\frac{1}{64}$ in. per ft.

(C) Average total horizontal expansion of walls composed of both old and new brickwork = $\frac{15}{32}$ in.

(D) Average unit horizontal expansion of old brickwork after being out of operation for 6 years and then heated to operating temperature = $\frac{1}{64}$ in. per ft.

Established expansion curves give a unit linear expansion at 218 degrees F. = $\frac{1}{64}$ in. per ft.

Note: Wall No. 1 is excluded from the foregoing calculations owing to the fact that the doors are not in place on oven No. 1.

Maximum horizontal expansion to date = $\frac{7}{8}$ in. and occurred in wall No. 17.

Minimum horizontal expansion to date = $\frac{1}{16}$ in. and occurred in wall No. 1.

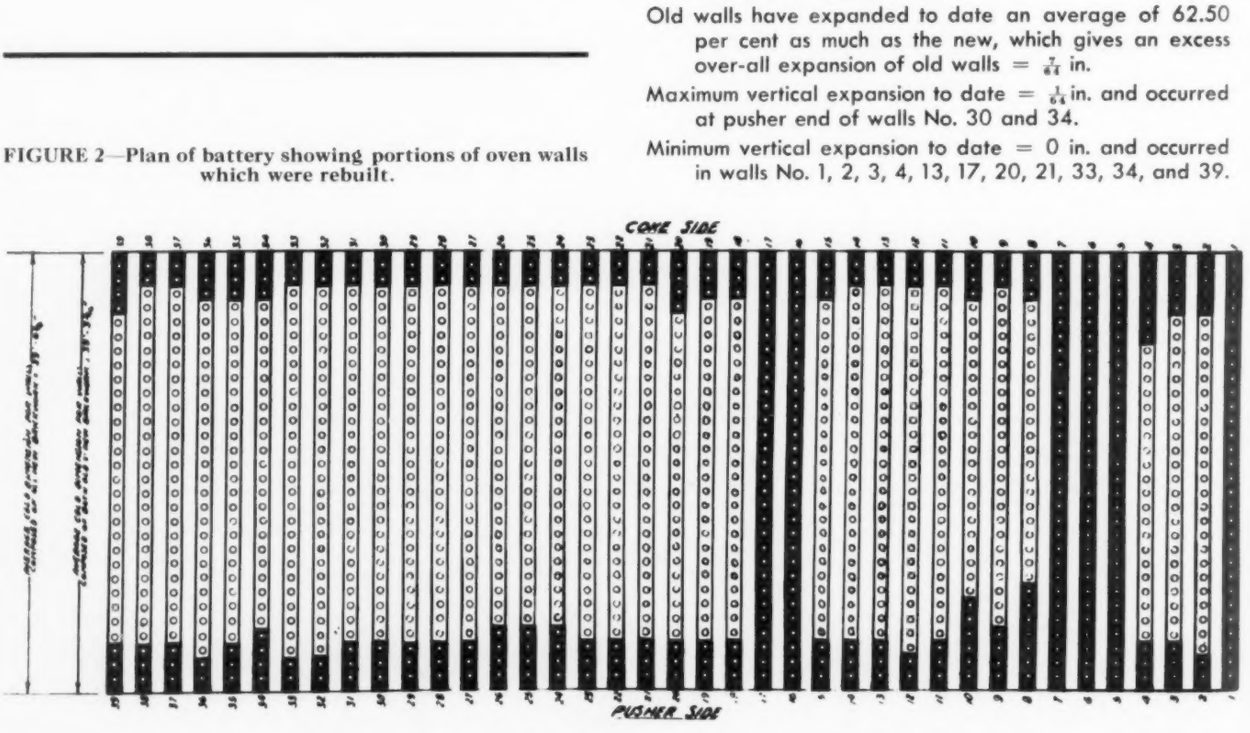
Old walls were designed to expand in length 61 per cent as much as the new walls.

Old walls have expanded to date an average of 62.50 per cent as much as the new, which gives an excess over-all expansion of old walls = $\frac{7}{64}$ in.

Maximum vertical expansion to date = $\frac{1}{64}$ in. and occurred at pusher end of walls No. 30 and 34.

Minimum vertical expansion to date = 0 in. and occurred in walls No. 1, 2, 3, 4, 13, 17, 20, 21, 33, 34, and 39.

FIGURE 2—Plan of battery showing portions of oven walls which were rebuilt.



spection plugs were dislocated and large cracks in the pavement occurred so that water could and did run into the oven brickwork. In addition, the lorry car passed across the top of these ovens as often as necessary to charge the thirty ovens in battery No. 3, which is situated north of battery 2-B and was in constant operation during the time No. 2-B was idle. In short, no effort was made to take care of the battery as it stood.

The oven structural work was also in very bad condition. The standpipes and other steel work were badly corroded and the damper valves, charging hole castings, inspection castings and other cast iron trimmings were badly broken up, so that during the year 1935 much of the equipment had been removed and scrapped. The cross tie rods had been so badly over-heated, and had rusted, so that they were in no condition for further use. Even most of the oven doors which were yet serviceable when operation of the battery was discontinued had been appropriated for use on other batteries of the plant. The air boxes were in very poor condition due to overheating and subsequent deformation. The adjustable butterfly valves were no longer adjustable—most of them could not be moved at all.

Early in the year 1935 it became a well recognized fact at Woodward that coke made from Pratt seam coal on a 22 to 24 hour coking schedule gave better results in the furnaces than that produced with a coking time of 18 to 18½ hours, the coking time necessary at that time to produce the amount of coke required. In casting about to determine what could be done, a careful inspection of 2-B battery was made and it was decided that the unit could be repaired and operated if necessary. Conditions at that time were such that the expenditure of an amount of money necessary to rebuild this group of ovens completely, as had been done in the case of 2-A battery, was practically out of the question. Yet there were so many good reasons for wanting to obtain the additional capacity to be had from these ovens that the estimated cost of making repairs to the battery appeared to be amply justified provided the work was successful. Therefore, it was decided to proceed with the repair job instead of a complete rebuilding.

Preparations were started and orders were placed for the necessary special shapes to rebuild six walls completely and the end flues of all the other walls in the battery. The six walls replaced were scattered through the battery and were so badly bowed and crooked that no part of them could be saved. About the first of August material was received and repairs were started with a force of twenty to twenty-five bricklayers working one eight-hour shift five days per week. The work was distributed on both pusher and coke sides and also on top the battery to the best advantage.

One of the greatest interferences encountered was the necessity of operating the lorry car over the top of the battery throughout the repair period. This delayed the work on the top of the battery considerably and prevented the building of a shed over the work to keep the rain out. For this reason great care was taken to protect the new work at all times with waterproof covering.

The ends of the walls were torn out and repairs were made in groups of two or three in order not to loosen up too much brickwork in any one region. This work extended from the top of the battery down to and including the gun brick, and in most cases a corresponding portion of the regenerator walls down to the mat and for a distance of from two to seven flues from the doors as required. The remainder of the brickwork seemed to be in very good condition. As soon as the brickwork was completed on any wall the cast iron lintels and new type cast iron jambs, made in five sections per wall, were set, and the entire wall then supported against the old buckstays by means of wooden wedges. The six complete walls rebuilt were constructed at the same time and supported in the same way. Lines were established to allow for four inches expansion horizontally in the old walls and five and three quarters inches in the new walls, calculated to bring the walls all in line at the buckstays after heating. After the lines were established and expansions calculated it was evident that, if standard cross sectional areas were maintained in the flues throughout, the walls in the repaired battery when heated would be from two to three inches longer than those in battery 2-A, and that most of the difference would occur on the coke side of the battery. To make the adjustment a standard 7 in. jamb casting was used on all walls on the pusher side but a more shallow casting measuring 5 in. in depth was used on the coke side. The vertical expansion was calculated, using the same co-efficients of expansion for old walls and new walls as used for horizontal expansion, and the new walls were built to come up to the old walls when heated. After heating, it was found that the average longitudinal expansion of the old walls was 4¼ inches, compared to the estimated 4 inches, and the average of the new walls was 5⅝ inches, compared to the estimated 5¾ inches. However, the actual vertical expansions did not prove to be as close to the estimated expansions as in the case of the longitudinal expansions. In estimating the vertical expansions the same factor was used in calculating the differential between old walls and new wall as in estimating the longitudinal expansion. This was an error because the cracks existing in the battery when cold were predominantly vertical cracks, and the absence of horizontal cracks caused the old walls to come up about forty per cent farther than was expected. The net result was that when the heating was completed the six new walls were 1¼ inches lower than the old, and it was necessary to repave the top at these points.

In joining the new work to the old, great care was taken to keep each course in good alignment throughout. Sometimes it was necessary to do considerable cutting of shapes to make them conform to the old work, which had considerable variation at certain points from measurements indicated on the drawings. An additional precaution, taken to keep the individual courses of the new work in close alignment with the old work, was the insertion of a ⅛-inch layer of straw board at every third joint in the new work to compensate for the theoretical differences in expansion. The results obtained proved the value of this care, since at this time it requires careful scrutiny to determine where the new work joins the old, and in many cases it is impossible to detect it at all.

At several points in the battery flues were found which had been overheated to such an extent that

fluxed material had sealed the flue completely at or near the bottom, in walls which were otherwise straight and in good condition. In these cases liners were removed at the points where this condition existed, the fluxed material cleaned out so that the original cross sectional area of the flue was restored, and a new liner set in the wall. In the entire battery there were about ten or twelve flues which required this special attention and, to date, no trouble has developed with these patched flues.

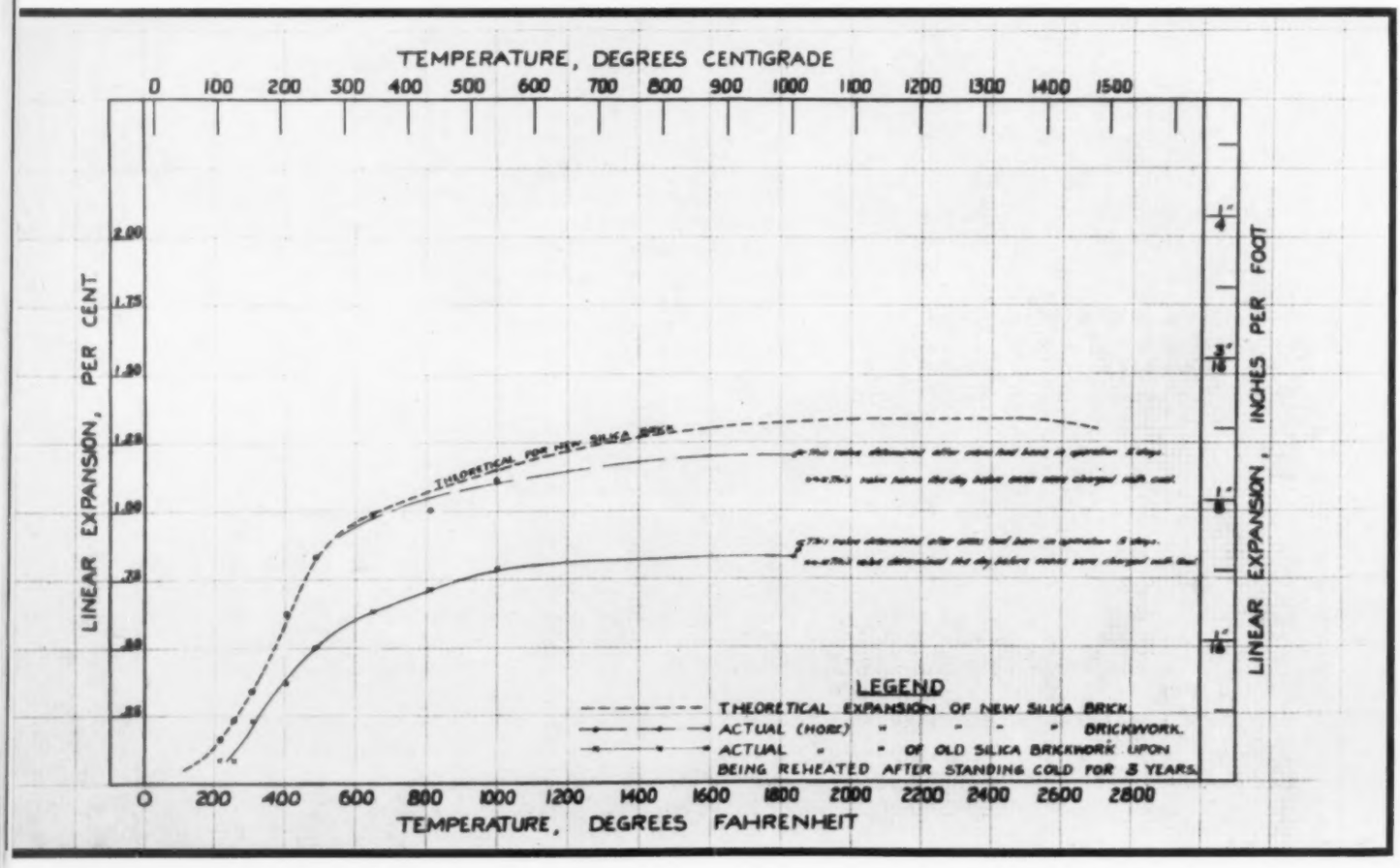
The bottoms of all ovens were very thin so it was decided to remove the floors and replace them with new floor liners throughout. In addition the first course of wall liners were badly gouged from one end of the ovens to the other. This condition was corrected by filling with a standard patching material.

The regenerators were found to be in very bad condition. In many cases the checkers were fused into a solid mass, and in all cases the checker work was congested with a large amount of foreign matter. All regenerator chambers were opened, the checker brick removed and sorted to eliminate defective brick. The regenerator walls were repaired by rebuilding at the ends and carefully pointing the walls and roofs throughout, and the checkers re-set on the same setting as was used when battery 2-A was rebuilt. This was done to create the same conditions in both 2-A and 2-B batteries since stack draft conditions on both units are controlled by the same stack dampers. A shortage of checker bricks, caused by the discarding of defective brick, was made up with new brick of the same size.

As the repair work was completed on each wall, and the inspection blocks and castings were set, and before the checkers were re-set, all the old nozzles were removed and the flues carefully cleaned from the top, allowing the loose material to fall through the air ports into the empty regenerator chambers. The gun bricks were carefully cleaned and pointed, nozzle wells built up where necessary, and new nozzles set in position. Charging hole castings were then set and the lids were sealed with pitch to keep out as much moisture as possible. Pitch was also used to seal all other openings on top which would admit water. At first it was intended to delay the paving of the top of the battery until the heating was completed, but this plan was changed and the paving was laid before heating because of the absence of the usual protecting shed. The top of the battery was crowned, so that the center is two and one half inches higher than the coke side and pusher side edges, to provide ample drainage. The openings for standpipes were sealed with pieces of light steel plate cut to fit and set in pitch.

As previously mentioned, it was necessary to operate a lorry car over the battery throughout the period of rebuilding. In order to do so, where ever it was neces-

FIGURE 3—Expansion curves showing actual determination made on old and new brickwork,


TEMPERATURE, DEGREES CENTIGRADE
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500
LINEAR EXPANSION, PER CENT
2.00
1.75
1.50
1.25
1.00
.75
.50
.25
LINEAR EXPANSION, INCHES PER FOOT
LEGEND
THEORETICAL EXPANSION OF NEW SILICA BRICK.
ACTUAL (HORE) " " " " BRICKWORK.
ACTUAL " " OF OLD SILICA BRICKWORK UPON
BEING REHEATED AFTER STANDING COLD FOR 3 YEARS.
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800
TEMPERATURE, DEGREES FAHRENHEIT

sary to rebuild an entire wall, the lorry rail was supported by means of two additional rails one on each side of the lorry rail. During the building of these walls the openings were always covered with corrugated steel which proved to be adequate protection even though many hard rains occurred during the time of rebuilding.

The buckstays were removed and replaced with new ones throughout, except for a single group of five on the coke side which were still serviceable. These were changed after the repairs to brickwork were completed. After the old nuts were removed by splitting, the tie rods at the base were found to be as much as a quarter of an inch undersize between the nut and the concrete mat, but it was finally decided that they were still satisfactory for further use. The threads were cleaned up by running a die over them, and new nuts installed. The cross tie rods on top were renewed throughout. The buckstays were then plumbed and made tight preparatory to heating up.

The air boxes, all of which were in very bad shape, were removed and completely repaired by the installation of new butterfly valves and quadrants. Twelve new boxes were provided to replace an equal number which were beyond repair.

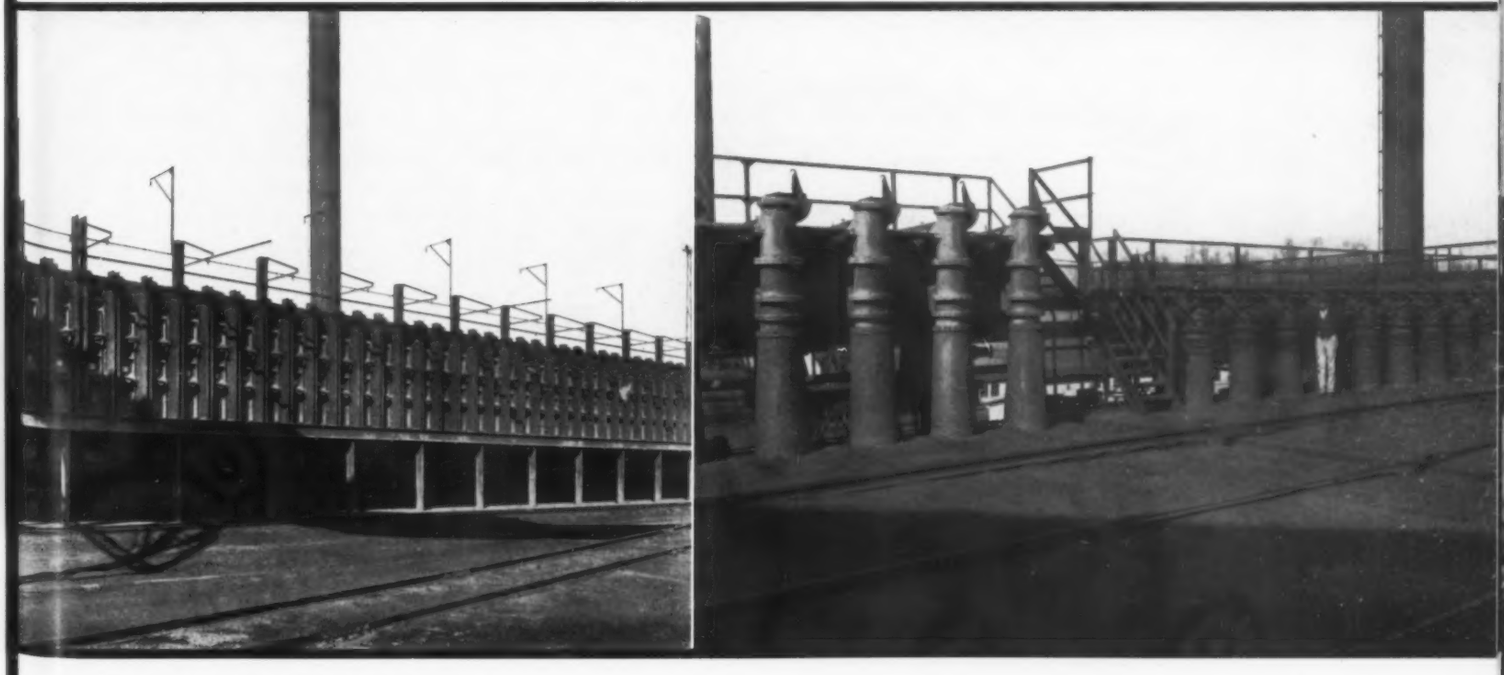
The gas guns were revamped by fitting extensions about six inches long to the ends inserted in the gun brick to compensate for damages previously done. The gas main was removed from both sides, thoroughly cleaned both externally and internally, painted outside, and replaced, together with new reversing cocks provided with pressure grease lubrication. The emergency cut off cocks were salvaged.

New steel and concrete benches were installed on both sides. In rebuilding the coke side bench, the same type of construction was used as existed on No. 2-A and No. 3 batteries in order to permit the use of the bench type door machines already in use on these batteries. This eliminated the two overhanging door machines of obsolete design formerly used on No. 2-B battery, thus reducing the number of door machines required on the entire plant by two, making one type of door machine standard for all these batteries, and eliminating the steel work required for the overhead door machines which would have been costly to install and expensive to maintain. The steel work was erected before heating the battery, but the concrete was not poured until afterward. New doors, patterned the same as those used on the plant generally, were furnished throughout, and the same procedure was followed with respect to charging hole lids and castings and the inspection hole castings.

The collecting main is a "D" shaped main with the gas inlets applied at the same elevation throughout. The top is level and crowned slightly to afford good drainage. The top of the main also serves as a walkway. The special "D" shape was adopted at the request of the operating department, to provide for standpipes of uniform height. The bottom of the main is sloping to the extent of thirteen inches per hundred feet of length with a pitch trap applied at one end. The main is located in such a position with reference to the top of the battery that the standpipes are only 4 ft. 8½ in. high. This short standpipe is a decided advantage in many ways, not the least of which is the position of the standpipe lid and damper box, which is easily accessible from the top of the battery. The water sealed valve used for dampering off is of the plug type, located inside the main, and operated by means of a handle extending

FIGURE 4—View from coke side of battery after rehabilitation work was completed.

FIGURE 5—Top view showing relative heights of old type and new type stand pipes.



through a packing gland. The damper box is short and slopes downward toward the main so that the spray nozzles, located at the high point, keep the box thoroughly sprayed without any danger of cooling liquor getting into the standpipes and ovens. No trouble has been encountered in keeping the opening in the valve clear at all times as very little carbon deposit of a lumpy nature is formed in the damper box. The crossover main and butterfly regulating valve were renewed because the old main was too thin for further use. The new main is of the self supporting type so that no bridge is necessary. The walkway is located above the main and supported by it.

When the air boxes were removed to repair them, it was found that the openings into the waste gas flues were in such condition that the boxes could not be replaced until repairs were made, and further investigation revealed the rather startling fact that the brick lining of both flues had collapsed, so that both side walls and arches were lying in the bottom of the flues. Because the flues themselves are considerably oversize no trouble had been encountered in conducting the waste gases from the 2-A battery in spite of this condition. Steps were then taken to replace the flue linings as soon as the oven brickwork was completed.

In order to permit the operation of 2-A battery without interruption, a fan of ample capacity, which was available in surplus equipment, was set up at the end of the 2-A battery opposite from the stack. An opening was cut into the top of the pusher side flue at this point and connected to the fan by means of a large sheet steel duct with a suitable damper. Next a large opening was cut in the top of the flue at a point between 2-A and the 2-B batteries, and an eighteen inch bulkhead was built dividing the flue at this point. About two hours were required to build this bulkhead, working bricklayers in relays on account of the heat, and during this time no gas was burned for heating. When completed, the fan was started, the regulating damper at the stack end was lowered, and heating was resumed with the fan substituted for the stack when gas was burning on the coke side. When repairs were completed on the pusher side, the procedure was reversed to permit repairs to the coke side flue. Expansion joints $\frac{3}{4}$ in. wide were provided every twelve feet in the new lining.

One of the reversing cast iron dampers was found to be badly cracked near the bottom, with a section about six feet square missing, so the lower section was replaced with a steel plate, and some patch plates were placed on the upper portion to re-enforce the points where cracks had appeared. The damper guides, which are built of brick, were repaired also.

When the air boxes were removed, the special shaped blocks supporting the boxes were found to be in very bad condition. Since this is a large block made with its lower side curved to conform to the radius of the top of the arch, and its replacement of brick would have caused a long delay in the completion of the work, a special cast iron shape was designed and made to support the box. These were speedily obtained from a local foundry. The use of cast iron at this point apparently is satisfactory in every way, and offers more resistance to disintegration than the brick shapes used originally.

During the time required to complete repairs to the stack flues, preparations were made for heating by the installation of temporary checker work in both ends of each oven, and the new doors were placed in position. Each door was provided with an opening near the bottom of sufficient size to freely admit a $\frac{3}{4}$ in. burner pipe. Heating was begun October 16th., by means of small flames placed in the ovens of even number on one side and those having odd numbers on the other side. At the end of twelve days the other half of the burners were lighted and the heating was continued so that a uniform increase in temperature was obtained from day to day. Temperatures were taken by means of portable instruments with the thermocouples located about two feet below the horizontal flue. Enough caps were stripped on top to permit the moisture and products of combustion to escape from the ovens through the by-pass connections, and at the same time maintain a pressure of about 1 millimeter on the flue system.

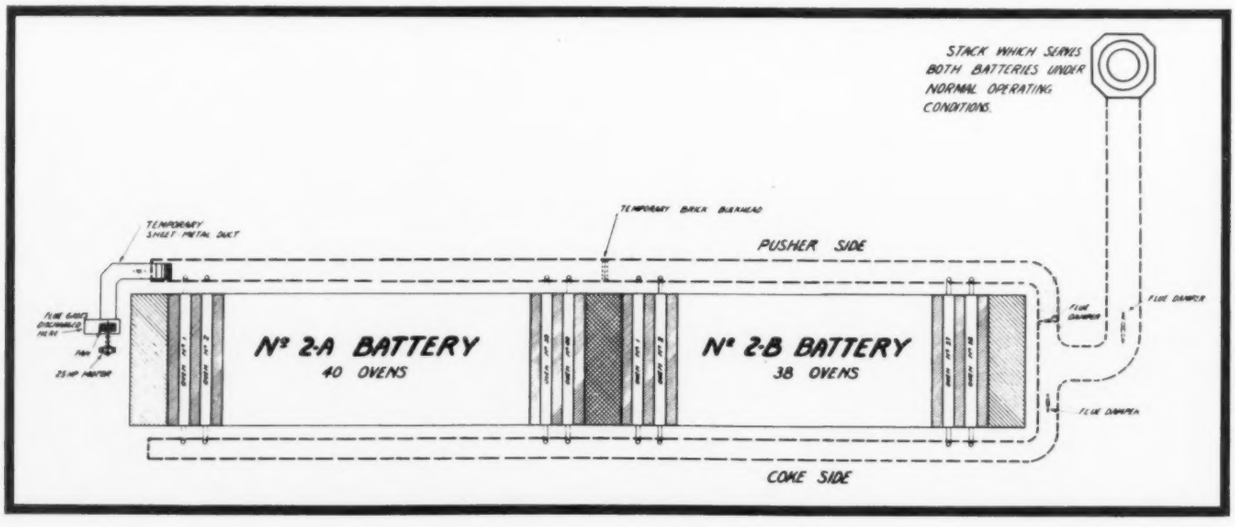


FIGURE 6—Diagram showing scheme for drafting the battery while repairing main stack flues.

This procedure was continued for a total of thirty days until the temperature reached 435 degrees F. and most of the moisture had been driven off. The butterfly valves in the air boxes were then opened sufficiently to conduct the waste gases through the regenerators to the stack. All inspection caps were then placed in position on top.

At the end of eighteen days the average temperature had reached 285 degrees F. There arose a question of policy as to whether the demand of coke, which was falling off rapidly, would justify the continuation of the heating process at this time. After a period of seven days during which the temperature was maintained at 285 degrees F. it was decided to proceed with the heating and temperatures were raised at a uniform rate until December 1st, when the average temperature was 1800 degrees F. On this date the gas was lighted in the flues, and during the next two days the by-pass plugs were inserted and checkers removed from the ovens. This completed the heating and the battery was charged on December 8th. The net time required for heating was 53 days and there is little doubt that this time could have been reduced somewhat if it had been necessary to do so, but it was decided to take plenty of time due to the fact that both old and new brickwork were present. Final results indicated that the time was very well spent.

The battery was charged in the usual manner and pushed on a thirty-hour coking time schedule for six or seven days to allow the regenerators to come up to full temperature and other adjustments to take place. A remarkable feature of this part of the program was the small amount of leakage encountered in the flues. In fact, four days after charging, the back pressure had been raised to five millimeters, which is the same as is carried on all other batteries at this plant, and leakage had practically disappeared.

These ovens have now been in operation fifteen months. Some 175,000 tons of coal have been carbonized, and there has been no indication whatever of any trouble developing with the oven operation. No complications have arisen to interfere with the heating and the coke temperatures are very uniform throughout. No provision was made for metering the fuel gas used, so it is impossible to offer any data to show actual practice in heating, but there is reason to believe that the amount of gas required compares favorably with that used on the other batteries.

From time to time gas samples have been taken from individual batteries for analysis. Results indicate that 2-B battery produces the best gas in the plant and the calorific value of it is about 10 Btu. higher than the average for the entire plant. By-product yields have increased also, mainly for the same reasons.

When one considers that the battery was built over twenty-five years ago, and reviews the history of its operation throughout its life, the fact that it was possible to rehabilitate it by the work done and described here is sound evidence that the original design and construction were of the best, and it is the consensus of opinion that the battery is now capable of normal operation for an indefinite period of years.

It has been said previously that the primary purpose of rebuilding this battery was to obtain additional oven capacity in order to make coke at Woodward using longer coking time than was possible without them. The cost of the work has been amply justified by the results obtained at the furnaces. The coke is harder and cleaner, and will carry more burden with reduced dust production and an average coke consumption 175 lb. less than before when operating under the same conditions.

The furnace operators state, also, that with this type of coke it is much easier to control the composition of the iron produced, especially with reference to silicon content.

FIGURE 7—View of top of battery after repair work had been completed.

Speed CONTROL by Voltage CONTROL

By R. A. GEUDER

Steel Mill Section

RELIANCE ELECTRIC & MANUFACTURING COMPANY

CLEVELAND, OHIO

Presented before A. I. & S. E. Chicago District Section, January 10, 1939

▲ A NEW way to consider voltage control is to think of it in terms of adjustable speed from the alternating current power source of supply. With the ever-increasing demand for high speed, high quality and low cost, the raw material manufacturer is being faced with additional problems every day in making use of his machines and adapting them suitably to handling all classes, types, sizes, and shapes of materials. Inevitably this results in the necessity for adjustable speed. There are many combinations available for producing adjustable speed such as the variable speed mechanical drives, adjustable pitch pulleys, special motors, commutator type a-c. motors with adjustable secondary voltage, etc. The all-electric drive by voltage control provides a real, simple, flexible and complete wide range means of adjustable speed. The speeds are adjustable and remain substantially fixed under varying load conditions.

Variable speed control such as a slip ring motor or a series motor, while it does provide some range of speed, gives speeds which are nevertheless dependent on load. Voltage control, however, adjusts the speed, and it remains fixed even though the load varies over wide ranges. In other words, we differentiate between adjustable speed and variable speed, in that adjustable speed is a means whereby the speed of a motor can be changed purposely but the speed will remain substantially fixed even though the load varies appreciably. Contrasted with this is variable speed; while it does provide some speed change of the motor, this speed change is dependent upon the load on the machine. It is true that the speed can be changed intentionally while the machine is loaded or for the same load the speed can be adjusted, but just as soon as the load varies, the speed varies also.

Since we are considering simple all-electric means of obtaining adjustable speed over wide ranges, we may pretty well limit ourselves in this discussion to a comparison of adjustable-speed direct-current motors and voltage control motors.

The first point of comparison is constant horsepower versus variable horsepower. Figure 1 shows characteristics of a typical 15 hp. motor, adjustable speed, 600 to 1800 rpm. by field control, and also of a 5/15 hp., 600 to 1800 rpm. motor by voltage control. Notice that while the adjustable speed motor gives a speed range of 600 to 1800, or in other words a 3 to 1 speed range, the voltage control motor speed range is almost unlimited in that it can be slowed down below 600 rpm. and give a range of 6 to 1, 8 to 1, 10 to 1 or an almost infinite range.

The chart also shows the same facts in comparison of torque. Notice that the field control motor provides a variable torque which is high at low speed and low at high speed, while the voltage controlled motor's torque is constant.

These charts bring out forcibly the flexibility of voltage control, giving speeds from zero to 1800 rpm.

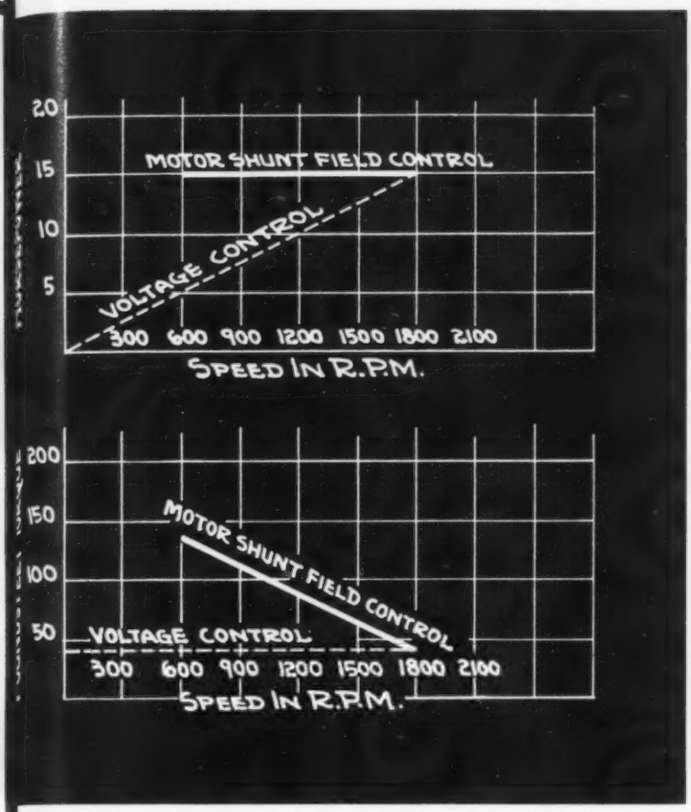


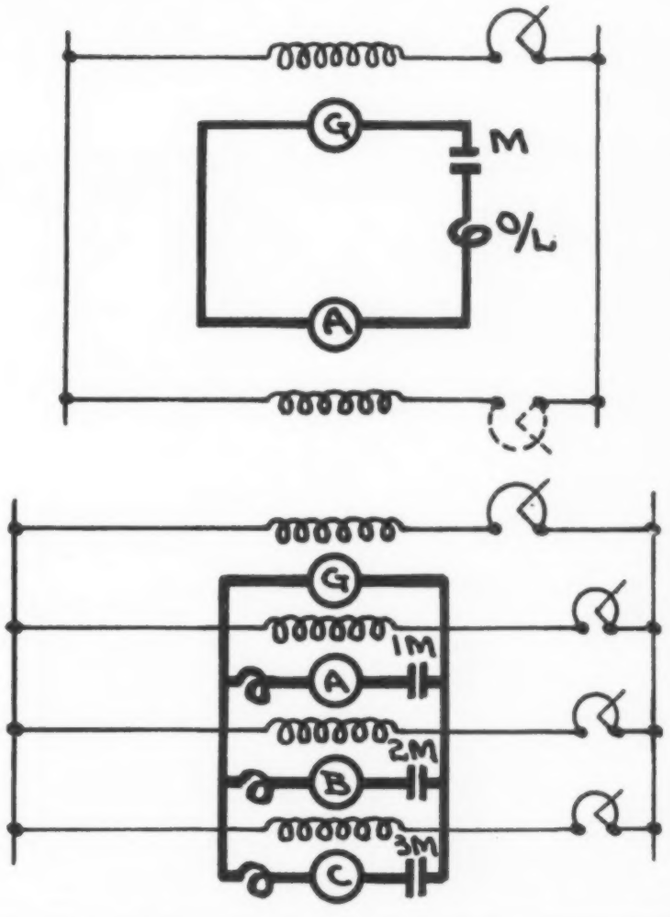
FIGURE 1—Characteristics of 15 hp. adjustable speed motor with field control, and of 5/15 hp. motor with voltage control.

must be a constant if the line voltage is constant and the IR drop is constant, we can juggle speed and flux as we will so that the product of the two multiplied by some constant K will still give us a fixed counter emf. Similarly, to slow down the motor, if we strengthen the flux or increase its value, the value of S must decrease, which, of course, means that in strengthening the field of an adjustable speed motor, the motor slows down.

Considering now a voltage control motor, we shall assume that the field flux remains constant. Therefore, if the field flux is constant and the IR drop of the motor is constant, the only way that we can change the speed (referring back to our original formula) is by changing E, the impressed armature voltage.

In both the field control adjustable-speed motor and the voltage control motor, the speed of the motor has varied directly in proportion to the counter emf. We

FIGURE 2—Diagram of voltage control systems, showing simple application at top, and tandem application below.



while the field control motor is limited to a shorter range. Field control motors have been produced giving a field control range successfully over 6 to 1. With some degree of satisfaction 8 to 1 motors have been produced and even as high as 10 to 1 by field control, but these motors are far from general-purpose commercial motors.

Perhaps right here it is desirable to pause to see how the speed of a direct current motor is changed. The fundamental formula is: E = cemf. + IR, where E is the line voltage impressed on the motor armature. The cemf. (electro motive force, generated voltage, or back emf.) is the counter voltage developed by the motor itself. The IR factor is the voltage drop within the motor caused by the flow of armature current through the resistance of the motor armature coils, commutating coils, brushes, etc. The cemf. factor is a function of the field strength or field flux Φ and the motor speed S, so that the above formula may also be written: $E = K \Phi S + IR$.

In a given motor, the IR factor is an inherent fixed value. Therefore, if we wish to change the speed S of a motor we must change either E, the impressed line voltage, or the field flux Φ. Hence, with an adjustable speed field control motor, to increase the speed S we have only to decrease the flux, that is, weaken the field of the motor. In other words, the formula E = cemf. + IR must always be satisfied for the motor to be in equilibrium. In other words, since the counter emf.

said that the IR drop was a constant, depending upon the characteristic drop of the particular motor in question, and its armature current. Therefore, the speed of the voltage control motor varies not exactly as the impressed armature voltage, but varies as the counter emf., which is the difference between the impressed armature voltage and the IR drop. The following shows how the motor speed does vary directly with the counter emf.:—

Line Voltage	=	cemf.	+	IR	Rpm.
110	=	100	+	10	1000
60	=	50	+	10	500
35	=	25	+	10	250
20	=	10	+	10	100
10	=	0	+	10	Stalled.

Notice that as the impressed voltage is changed, for instance, from 110 to 35 volts, which is roughly a 3 to 1 range, that the speed of the motor actually changes from 1000 to 250 rpm. or a 4 to 1 range. Notice also that as the impressed voltage is lowered to about one-sixth, that the speed of the motor is lowered to about one-tenth. It is further noteworthy in this particular case that when the impressed voltage is lowered to a value equivalent to the IR drop of the motor, the motor remains stalled and does not rotate at all. Therefore, in voltage control it is necessary to recognize the IR drop factor, particularly when extremely wide speed ranges are desired.

FIGURE 3—Diagrammatic analysis of a tandem drive, with calculations showing speed variations for various applied voltages.

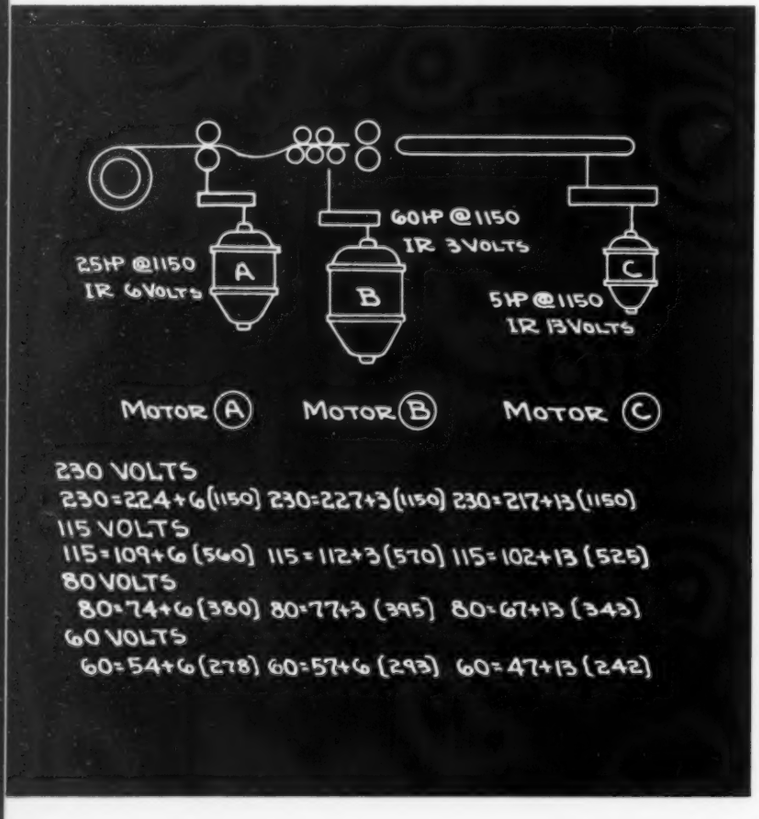


Figure 2, illustrates the simplicity of voltage control. The generator G is connected directly to the armature of motor A. Customarily on relatively small units it is only necessary to have one main line contactor and one overload in one leg of the loop circuit between the generator and the motor. It must be recognized that the same conditions do not exist in this type of apparatus as exist on a motor which is connected directly to the mill supply bus. On that mill supply bus we probably have a capacity of at least 10,000 kw. and the short circuit protection on that size of equipment, the safety of all other equipment on that same bus, and the danger with grounds on that bus as it influences all other equipment, present an entirely different problem than exists on a voltage control closed system.

In Figure 2 notice that the field of the generator and the field of the motor are both excited from a separate source of d-c. potential. By strengthening or weakening the field of the generator the motor speed can be raised or lowered. After the generator has raised its voltage to its full rated value, further increase in the motor speed could be effected by a rheostat in the field of the motor itself. In other words, we have voltage control from zero to full voltage and then for further speed range we can weaken the field of the motor by the motor field rheostat. This is really a combination of voltage and field control, commonly used where the load is a combination of constant torque and constant horsepower.

Figure 2 also illustrates a typical tandem application where two or more motors are simultaneously operated by voltage control from a single generator. Notice that each motor has its own main line contactor and overload. Notice also that the generator field as well as the motor fields are all excited from a constant source of d-c. supply. Each motor has its own vernier rheostat in series with its field which might be used either to give a combination of voltage and field control, or more probably is used to synchronize the various machines for tandem operation.

The tandem application of motors on voltage control brings out the significance of our fundamental formula: E = cemf. + IR.

Figure 3 gives a ready picture of a typical tandem drive. In this diagram we have illustrated a side trimmer, a flying shear and a conveyor, all of which are expected to be synchronized over an operating speed range of approximately 4 to 1. We have shown the relative IR drop under full load current conditions for each of these motors. For the 25 hp. motor the IR drop at full load current is approximately 6 volts, on the 60 hp. it is 3 volts and on the 5 hp. it is 13 volts. The chart quite clearly shows that at 230 volts we have selected motors which will all run at 1150 rpm., assuming that that is the speed at which the gearing has been selected and the synchronization is perfect. Now if we wish to drop to approximately half the speed

of this line, we will reduce our impressed voltage from our generator to 115 volts. On this condition, motor A is running a trifle slower than motor B, and motor C is running still a little slower than motor B. In other words, a slight vernier adjustment will be necessary in the fields of motors A and C to raise their speeds to correspond with motor B. Notice what happens as we reduce the impressed voltage still farther. We will see that when we get down to approximately one-fourth speed that while the relationship of motor A and B are still substantially close, the relationship of motor C to motor B has diverged a little farther and it will be necessary to insert a little more vernier adjustment in motor C to bring it back in line with motor B.

On specific applications this fact is recognized in the introduction of sufficient vernier rheostat control in order to take care of conditions such as these, and if the amount of vernier adjustment is to be minimized, then a more careful selection of motors might be made in order that the motors under full load conditions will all have approximately the same IR drop. It may mean a change in base speed of the motors or it may mean a change in the basic capacity of the motors.

Tandem applications of voltage control, where field control is superimposed upon the voltage control range, are very general, and while space will not be taken to cite or illustrate the whole list of typical applications, there are several illustrations which remind us of the flexibility and adaptation of voltage control.

In Figure 4 is a six-stand hot finishing mill where all of the motors are supplied by voltage control from generator sets in the motor room. Most of these motors have a field control range of about 2 to 1 which is used for synchronizing them accurately as the strip feeds from one to the next. While wide operating ranges are not usually used on these hot mills, it is not, however, unusual to operate at one-half normal voltage, which means about one-half of normal speed.

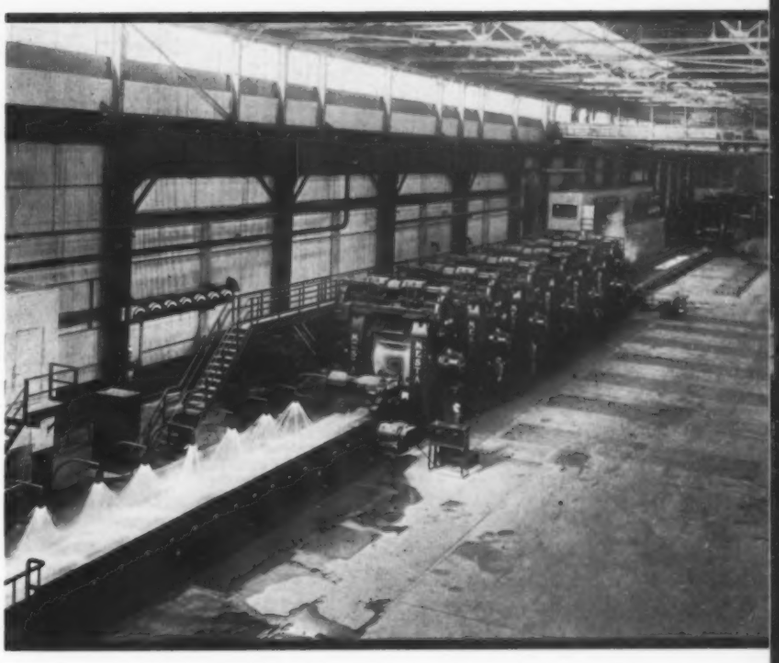
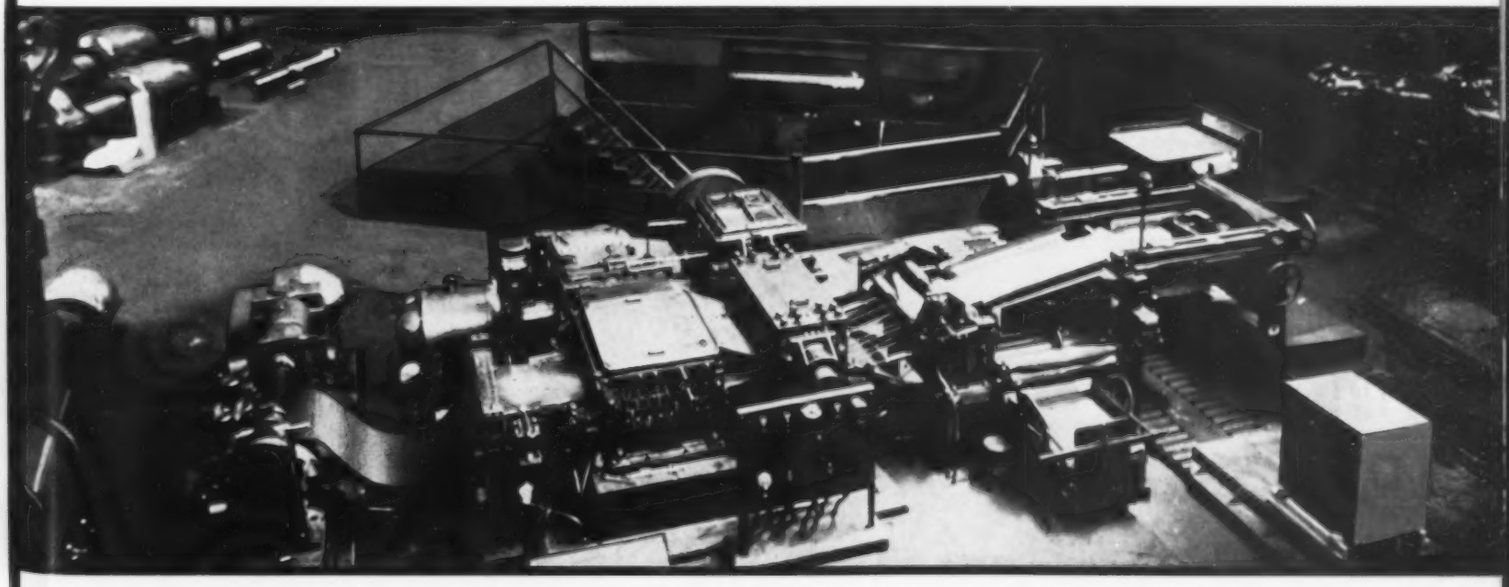


FIGURE 4—The finishing train of the modern hot strip mill is an excellent example of field control superimposed on voltage control.

In Figure 6 we have the physical picture of the tandem unit described in Figure 3. This illustrates a sheet shearing line where the coiled strip is brought first through a side trimmer and then through a roller level-



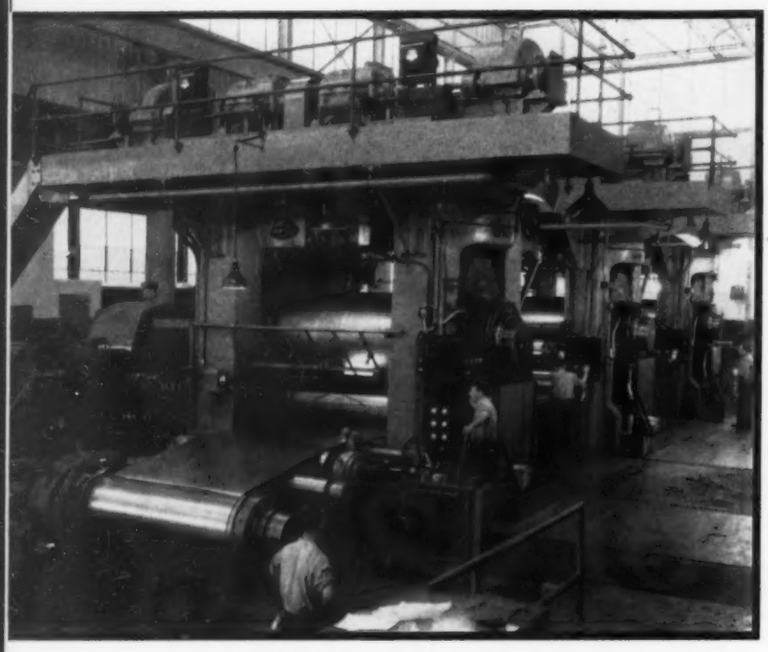


FIGURE 6—Tandem cold mills usually have a 2:1 field control in addition to a common voltage control set.

er and flying shear combination, and from there delivered to a conveyor. The units are operated by voltage control, and in this case the flying shear is the master unit, and the speed of the conveyor and the speed of the side trimmer are adjusted by vernier rheostats to match the speed of the flying shear. The operating speed range of a line like this is probably 4 to 1, and the proper selection of direct-current motors minimizes the vernier adjustments necessary.

In Figure 6 we show a three-stand tandem cold mill with tension reel where each of the main mill motors has a 2 to 1 field control range, and the reel motor undoubtedly has a 4 to 1 field control range. All of these motors are controlled from a common voltage control set, and acceleration and deceleration from slow threading speed to operating speed are controlled through voltage changes. Speeds as high as 1800 fpm. are obtained on mills such as these, particularly for rolling tin plate, and yet it is necessary in many cases to get down to a slow threading speed of 90 fpm. which represents a speed of 20 to 1.

In Figure 7 we have a galvanizing line in which the rollers within the galvanizing tanks, or rather the pinch rolls, are each controlled by their individual motor, with a spangle conveyor, a cooling conveyor and runout conveyors, all controlled from the same source of voltage control. These motors are provided with a field control range of approximately 2 to 1, a portion of which is used for synchronizing, and another portion of which is used for reducing the armature current losses when the speed of the line is reduced to very low values by voltage control. In this particular case the high ambient temperature, superimposed on the fact that these motors are fully-enclosed fan-cooled and fully-protected, introduces a problem which has not been touched in this discussion, but which must be recognized on applications such as this, and that is that the heat losses within the motor remain substantially the same in so far as the armature copper losses are concerned, as the speed is lowered by voltage control. There is some benefit gained from the reduced iron losses, but because of the slower speed after the speed has been reduced approximately 4 to 1, attention must be given to the selection of the motor characteristics so that the motors can successfully operate continuously at the very low speeds. If on this type of equipment, as on the tandem mills, forced ventilation were used for cooling, then the problem of motor heating would disappear, but the economics of this particular application do not warrant the introduction of forced ventilating equipment.

This short discussion of the fundamentals governing voltage control and the many possibilities of its application may be considered a success if it has suggested a new idea or an explanation for an old one which may result in doing a better job. Voltage control in itself is not new and has been used successfully for many years, but it is often wise to pause and reflect upon the ways in which an old tool can be put to new uses.

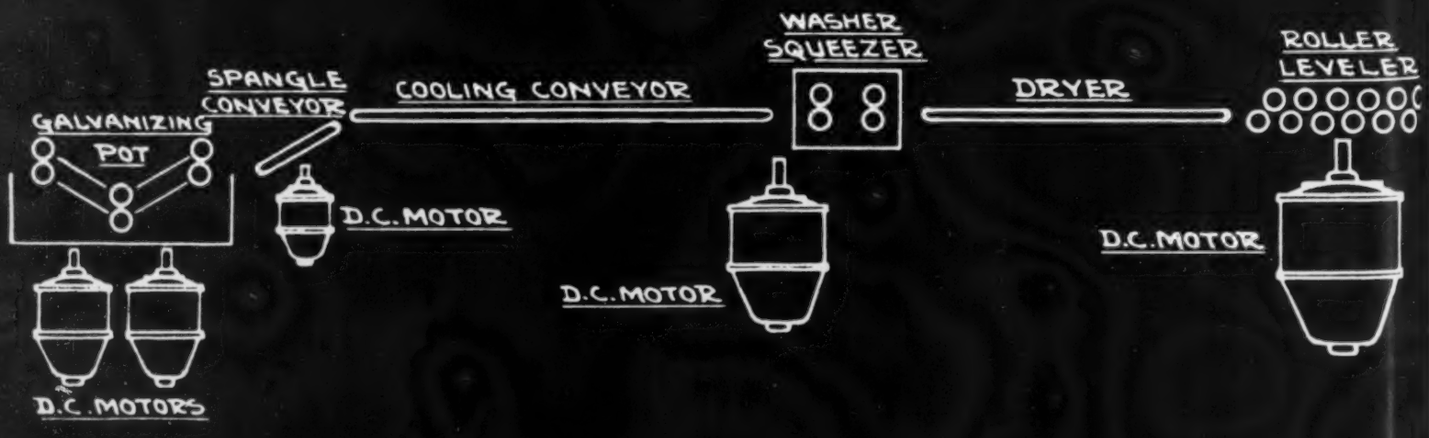


FIGURE 7—Diagram of galvanizing line, in which all motors are controlled from the same service of voltage control.

O. R. JONES, *Past President of the A. I. & S. E.,* DIES

O. R. Jones, formerly electrical engineer in charge of the Lowellville plant of the Sharon Steel Corporation, Lowellville, Ohio, died on June 18.

Mr. Jones' entire business background was spent in electrical engineering work, the majority of the time in the iron and steel industry. As a youth he attended the public schools of Youngstown, Ohio, and supplemented his subsequent practical experience as an electrical engineer with studies in Cleveland. In 1880, Mr. Jones installed the first electric light plant in the city of Youngstown. This installation was one of the earliest to be installed for commercial use, inasmuch as the first commercial electric lighting installation was made in this city. Citizens of the surrounding communities within a fifty-mile radius came by horse and buggy and on foot to see this new marvel of powerful light from a string of copper wire.

In 1897, Mr. Jones became affiliated with the Meadville, Pennsylvania, lighting plant, as electrical engineer in charge of the plant. After six years, he returned to Youngstown to become associated with the Youngstown Sheet and Tube Company as an electrical engineer. In this capacity Mr. Jones became of further service to the industry. The motorizing of the overhead electric crane was taking place and the motors used were of the type used on the electric street cars of that time. The mill-type motor had not as yet been developed, and it was at that time that Mr. Jones performed a great service, for he was one of the men largely responsible for the development of the large mill-type motor now in use in every large steel plant. After twelve years with the Youngstown Sheet and Tube Company, he left them to become an electrical engineer with the Sharon Steel Hoop Company, later known as the Sharon Steel Corporation, in charge of the Lowellville plant. He remained in this capacity for twenty-four years until his retirement in 1936.

Mr. Jones, who was one of the founders of the Association of Iron and Steel Engineers, took a keen interest in all of the Association's varied activities. He was elected President of the Association in the year 1915, and has served on numerous committees for the Society.

Tentative List of Topics for Technical Sessions

ANNUAL CONVENTION, 1939

"Yields of Coke and By-Products from Various Coals."

"Beneficiation of Iron Ores for Blast Furnace Use."

"Operating Results of Modern Blast Furnace."

"Economics of Advanced Engineering Planning."

"Developments in Rolling Flat Steel Products."

"Modernization of Existing Open Hearth Furnaces and Auxiliary Equipment."

"Steel Plant Refractories."

"Mixed Gas Systems in the Steel Plants."

"Heating of Steel from the Metallurgical Viewpoint."

"Gauge Control for Cold Strip Mills."

"Electrical Industrial Truck Application in the Steel Plant."

"Power Requirements of Hot and Cold Strip Mills."

"Vacuum Tube Control for Steel Mill Applications."

"Power Distribution System at the Alcoa Plant of the Aluminum Company of America."

"Changing from 25 to 60 cycle Power."

Symposium: "The Preparation of Steel for Subsequent Rolling."

"Modern Lubrication of Existing Equipment."

"Progress of Lubrication in the Steel Mill."

"Causes of Gear Wear and Failure."

"Stress Relief in Welded Structures."

"Welding Rail Ends and Joints in Crane Runways"

"Welding Electrodes and Their Applications."

Britain Adopts Continuous Strip Production

at Ebbw Vale

RICHARD THOMAS *and* CO., Ltd.

Installs First Wide Strip Mill in UNITED KINGDOM

By T. J. ESS *and* J. D. KELLY

Foreword

In accordance with the policy of informing its readers of the latest developments in the iron and steel industry, the IRON AND STEEL ENGINEER here presents a description of the new Ebbw Vale plant of the British firm of Richard Thomas and Company, Ltd. This recent addition to the United Kingdom's steel-making capacity follows advanced engineering practice in all phases, and includes continuous broad hot and cold strip mills of latest design, producing sheet and tinplate by the modern continuous cold-reduction methods.

This unit is the sixteenth to be covered in the series of articles on modern broad strip mills, published in the IRON AND STEEL ENGINEER. In collecting and preparing the material for this article, we are deeply indebted to various members in the Richard Thomas organization, and wish to express particular gratitude to Mr. J. D. Firth, Mr. S. E. Graeff, and Mr. J. R. Bottoms for their fine cooperation in this matter. The last two named are members of the Association of Iron and Steel Engineers, and are well known for their previous connections with various strip plants in the United States. We also wish to acknowledge the cooperation of Mr. T. J. Kauffeld, of Steelworks Design, Ltd., London, England, and of Mr. J. L. Young, United Engineering and Foundry Co., Pittsburgh, Pennsylvania.

FIGURE 1—Two batteries of coke ovens provide a daily supply of about 1600 tons of coke.

▲ FOR over one hundred and fifty years there have been iron and steel works at Ebbw Vale, a location in South Wales singularly favored with the presence of the raw materials essential to the production of iron and steel. About ten years ago, however, it became necessary for the Ebbw Vale Company to close down the major portion of its operations.

In 1935, Richard Thomas and Company, Ltd., acquired the property, including a plant site some two and a half miles long and three-quarters of a mile wide, five collieries and limestone quarries, and an iron ore property in Northamptonshire. After careful study, an integrated plant for the production of sheet and tinplate was constructed, capable of annually making 600,000 tons of finished and semi-finished products direct from the basic raw materials. Almost all of the old shops were torn down, and the new plant followed the modern lines of continuous production methods, with a few deviations contributing to added flexibility of operation.

COKE PLANT AND BLAST FURNACES

Coke producing facilities comprise an existing battery with a daily capacity of 600 tons of coke, and a new battery of 65 ovens, 40 ft. 8 in. long x 12 ft. 6 in. high x 16 in. average width. Each oven is charged with slightly less than 14 tons of coal, and with normal

operation the battery has a capacity of about 1370 tons of coal (approximately 1000 tons of coke) per day. Coal is handled by a complete conveyor system, crushed, and blended, passing then through hammer mills, and into a 3000 ton storage bunker. A four-hopper charging car serves the ovens.

The battery is designed for heating with blast furnace gas, being equipped with double regenerators. Pushing, quenching, screening, etc., are carried out in the conventional modern methods. A complete by-product and benzol recovery plant, including electro-cleaning of the coke gas, is also provided. Coke oven gas is piped to the steelworks.

There are two 500-ton blast furnaces, which have been rebuilt and modernized, and provisions have been made for the future installation of a third furnace. Ore is received from the mines in the sintered state, and ready for use. The ore yard will hold about 175,000 tons, and is served by an ore bridge of a total span of 208 feet. The ore bucket is of 10 tons capacity, and the bridge can handle 300 tons per hour. Limestone is quarried about seven miles away, transported over the company's railway system, and deposited in stock bins. Total bin capacity is 7000 tons. A lime kiln has been installed for burning the raw stone.

Blast furnace gas is cleaned in electrical precipitators to below .009 grains per cubic foot, and passed to a 2,000,000 cu. ft. gas holder for use in the steel plant. The furnaces are blown by three turbo-blowers, each rated at 36,000 cu. ft. per min. at 25 lb. pressure, and one 55,000 cu. ft. per minute machine.

Hot metal from the blast furnaces is taken direct to the steel plant, or may be put over a pig-casting machine.

Near the blast furnace site is a new boiler and power plant. Three 100,000 lb. per hour boilers, of bent tube design, were installed, designed for a 450 lb. per sq. in. steam pressure. They operate normally at 375 lb. pressure and 675 degrees F. steam temperature. This new capacity augments the previously existing battery consisting of two 40,000 lb. per hour and eighteen 20,000 lb. per hour boilers, all of 160 lb. per sq. in. pressure.

The entire steam demand of the plant is served by these boilers, which are designed for firing by powdered coal, blast furnace gas and coke oven gas. Coal usually handles the base load, with gas handling the fluctuations through a system of automatic controls. Three impact mills provide powdered coal for each boiler, while gas is burned in compound multi-jet burners which handle either blast furnace gas or coke oven gas, or a mixture of the two. Combustion chambers are water-cooled. Air preheaters supply air for combustion at a temperature of about 400 degrees F.

The water supply has a total hardness of 1.1 grains per gallon, and a silica content of .21 grains per gallon. Over 80 per cent of the organic matter and all suspended matter is removed by double coagulation and filtration, using sodium aluminate and aluminum sulphate. The

FIGURE 2—Two modernized blast furnaces, of 500 tons capacity each, provide pig iron for the steel plant.

feed water is then treated with caustic soda to raise its pH value to 8.5. After preheating and deaerating, it passes to the boilers where an after-treatment of sodium phosphate and organic material is received.

Electric power is generated by a high pressure turbo-generator of 12,500 kw. capacity, and three low pressure 5000 kw. units. Two large concrete cooling towers, each of 1,000,000 gallons per hour capacity, are provided for the turbine units.

STEEL WORKS

The steel works has a capacity of about 39,000 tons of ingots per month, and consists of three open hearth furnaces, with space for a fourth, and three Bessemer converters with space for a fourth. One 1400 ton mixer has been installed, with provisions for a second. Thus steel may be made by the open hearth, Bessemer or duplex process, giving great flexibility with low cost. A basic slag plant has also been installed.

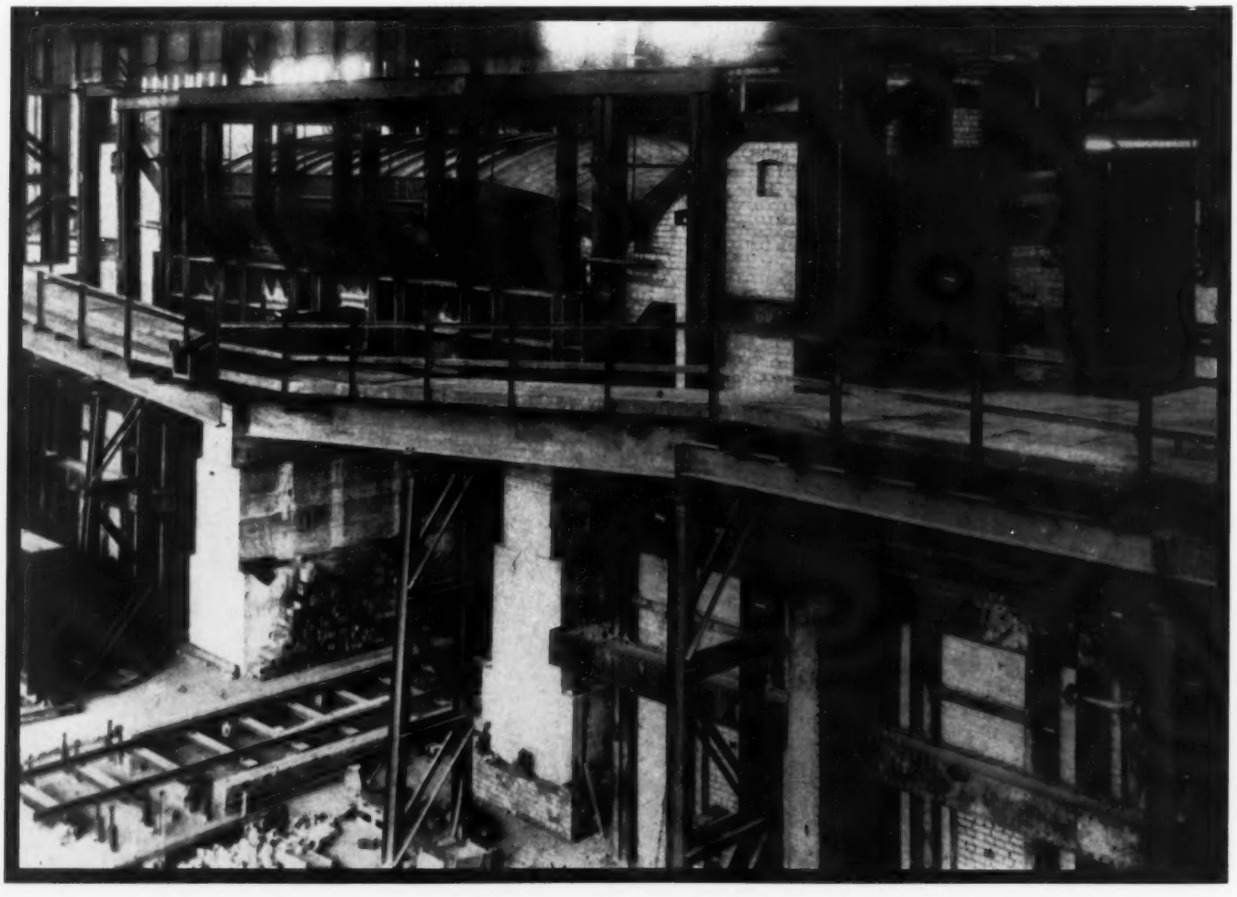
The main steelworks building is 1040 ft. long x 200 ft. wide. The open hearth department is located in one end of this building and the Bessemer department in the other end. The open hearth section is made up of a 65 ft. charging bay and a 60 ft. casting bay, both 640 ft. long. Charging machines of the low type run the entire length of the charging bay, and in conjunction with overhead cranes, feed the raw materials to the furnaces. The 75-ton furnaces, with hearths 38 ft. long x 13 ft. 6 in. wide, tap into ladles in the casting bay, which is equipped with three 140-ton ladle cranes. The furnaces may be fired with mixed gas or producer gas, and are of the venturi type, with sloping backwall.

In the Bessemer section is a bottom house, 240 ft. long x 50 ft. wide, provided with a 20-ton overhead crane. Five convenient bunkers provide capacity for storage of materials. The Bessemer shop proper is 400 ft. long x 65 ft. wide, and is a continuation of the charging bay of the open hearth shop.

Ingots of varying weight up to a maximum of 10 tons are poured and taken to the soaking pits, consisting of eight circular units of modern design. Mixed blast-furnace and coke-oven gas is introduced tangentially into the pits through small burners spaced around the pit near the bottom. Producer gas or oil may also be used as fuel. Temperature and combustion are automatically controlled. Gases leaving the pits pass through a port in the center of the furnace, and on to waste heat boilers, of which there are four, each of 3500 sq. ft. heating surface, designed for 200 lb. per sq. in. pressure. Approximately 500 lb. of steam is produced per ton of ingots heated.

Hot ingots are drawn from the pits by overhead

FIGURE 3—Open Hearth furnaces, of 75 tons capacity, are of modern design and construction.



crane and brought by ingot buggy to the blooming mill approach table, which is about 85 ft. long. The new slabbing unit is a two-high, 44 inch reversing mill driven by a 7000 hp., 50-120 rpm., 800 volt d-c. shunt motor, and capable of producing slabs up to 52 in. in width. The mill motor draws power through a Ward-Leonard control system from a motor-generator set consisting of three 1870 kw., 1800 volt d-c. generators, connected in parallel and driven at 600 rpm. by a 5000 hp., 11000 volt induction motor. Two 150 hp. d-c. motors with series-parallel switching operate the blooming mill screwdowns, which are equipped with remote position indicators. The mill pulpit is manned by two men, one handling the drive motor and screwdowns, the other operating the manipulator and tables.

The slab shear is driven by a 250 hp. slip ring motor, running continuously, with a clutch mechanism operated by a 5 hp. motor throwing the shear into and out of operation.

SHEET AND TINPLATE PLANT

Slabs leaving the blooming mill shear may proceed straight on to the hot strip mill without heating, or may be carried by a chain conveyor from the shear delivery table to the furnace charging table for hot charging into the slab heating furnaces, or carried by the chain conveyor to cradles in the slab storage building, where they may be chipped before reheating. The slab yard has a storage capacity of about 30,000 tons.

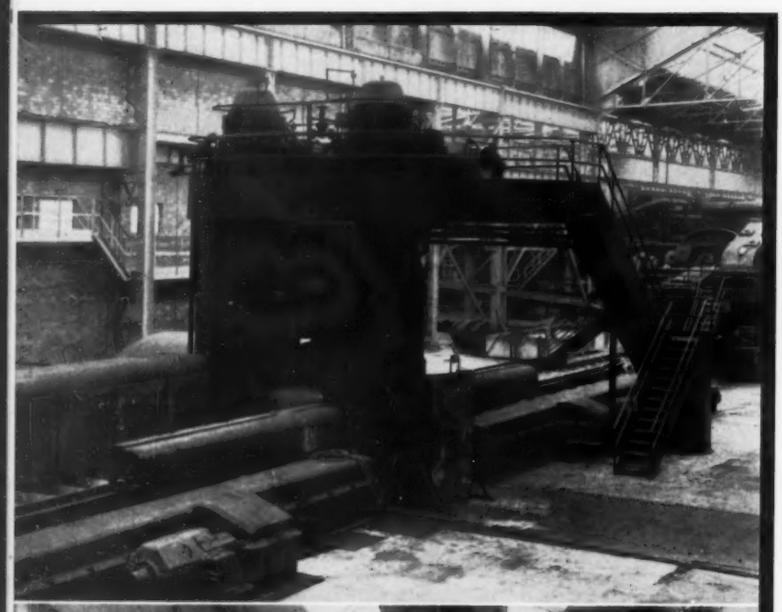
Cold slabs are brought by overhead crane to a magazine depiler, from which they are moved singly onto the furnace charging table, 140 ft. long, which runs across the back ends of the furnaces. Each furnace is equipped with a double head pusher, electrically operated through rack and pinion mechanism, so that slabs may be pushed through the furnaces in either double or single row.

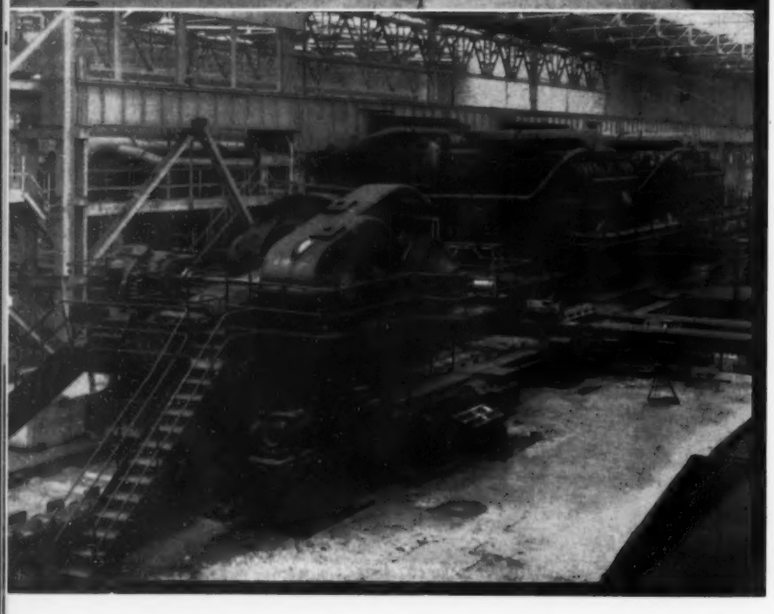
Sizes of slabs charged into the furnaces fall within the following ranges: 15-52 inches wide x $3\frac{1}{2}$-6 inches thick x 5-18 ft. long.

There are two continuous triple-fired furnaces, end charged, end discharged, each rated at 60 tons per hour. Effective hearth dimensions are 20 ft. width by 80 ft. length. Twenty feet of this length is devoted to a solid hearth soaking zone, while water-cooled skids carry the slabs through the main heating zone which forms the rest of the furnace.

The furnaces are fired with mixed blast furnace and coke oven gas of about 300 Btu. per cu. ft. The main heating chamber is fired top and bottom through six gas burners in each location, while eight burners overfire the soaking zone. Each of the three firing zones

FIGURE 4—Eight circular soaking pits of modern design provide heating capacity for the various sized ingots.





are separately controlled, with automatic fuel-air proportioning. Automatic controls are also applied to furnace temperature, furnace pressure and preheated air temperature. Gas and air flow to each zone is metered, with a totalizing meter for each furnace. Water flow to the skid pipes in the furnace is also measured.

Refractory tile recuperators placed beneath the hearths of the furnaces in a two-chamber arrangement preheat the air used for combustion to temperatures of about 800 degrees F. The air is pulled through the recuperators by motor-driven high temperature fans. Waste gases from the recuperators are exhausted through two waste heat boilers, each of 7500 lb. per hr. evaporative rating.

HOT MILL.

Motivated by the furnace pushers, the hot slab is discharged from the furnace over inclined skid plates against heavily designed bumpers located on the furnace discharge table, which is 125 ft. long. Proceeding along this table, the slab approaches the first unit of the hot mill, a two-high, 24 in. x 56 in. scale breaker driven through a double gear reduction by a 600 hp., 500 rpm., 440 volt motor. Scale loosened by the slight reduction in this stand is removed by hydraulic descaling sprays. Following the scalebreaker at a distance of 17 ft. 9 in. is a slab squeezer, driven by a 700 hp., 500 rpm., 230 volt d-c. motor, serving to square up slabs and size them to width.

Three two-high, 32 in. x 56 in. roughing stands come next. The first stand is placed 25 ft. 10 in. from the squeezer, while the rest are located at center line spacings of 39 ft. 1 in. and 59 ft. 11 in. These stands all have double reduction gear drives. The fourth rougher, located 83 ft. 1 in. distant, is a four-high, 21 in. and 46 in. x 56 in. stand, driven through a single gear reduction. Each of the four roughers is driven by a 2500 hp., 500 rpm., 11,000 volt synchronous motor.

The second and fourth roughing stands are equipped with integral edgers, driven by a 200 hp., 400/950 rpm., 230 volt d-c. motor mounted on top of the mill housing, and using rolls with a body approximately 8 in. long x 25 in. diameter.

FIGURE 5—The 44 in. reversing slabbing mill can produce slabs up to 52 in. in width.

FIGURE 6—View of slabbing mill motor-room, showing 7000 hp. main drive, with its motor-generator set and control board.

FIGURE 7—Product from the slabbing mill is sheared on this slab shear located ahead of the slab re-heating furnaces.

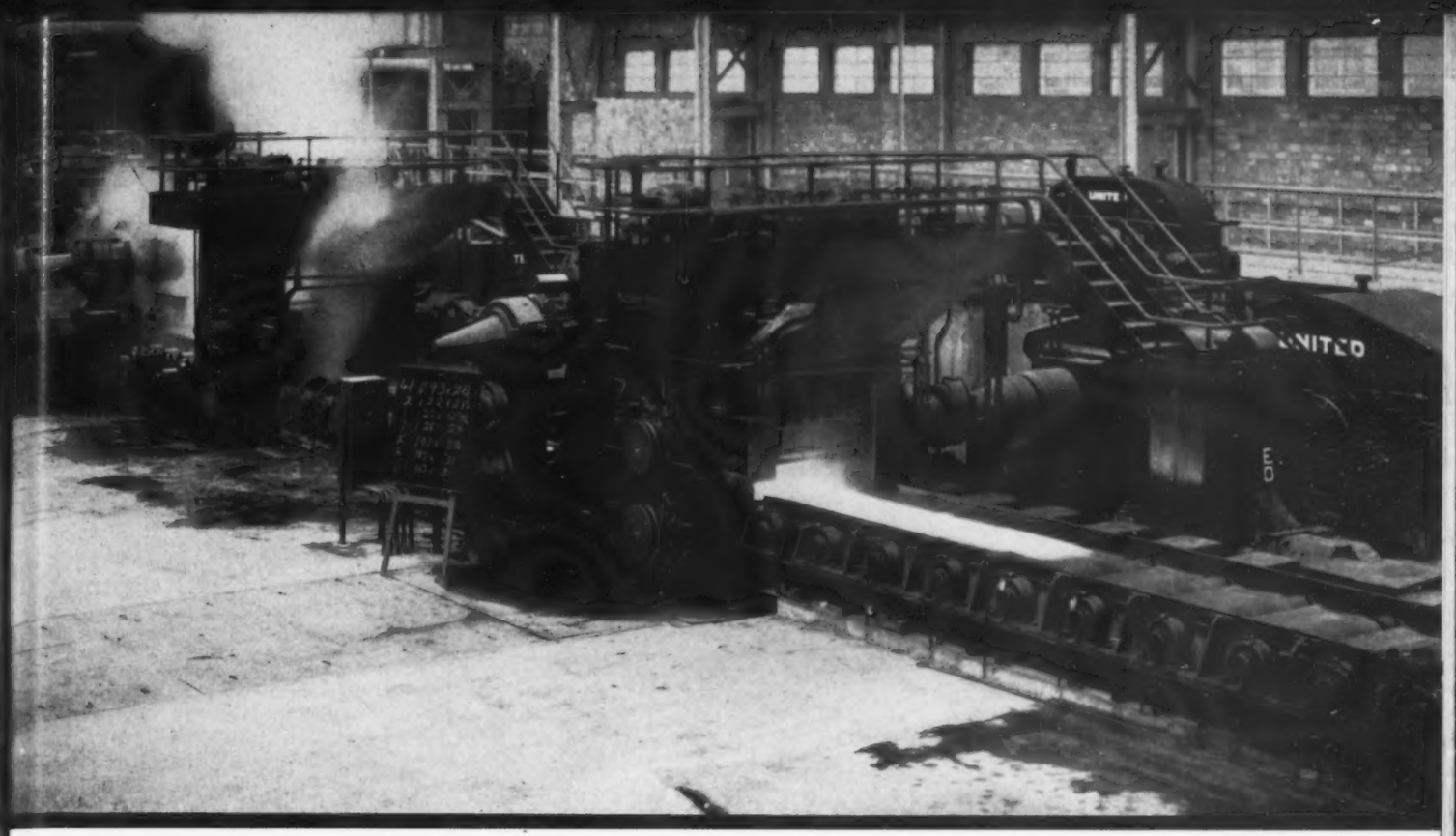


FIGURE 8—The roughing train consists of a scalebreaker. three two-high stands and one four-high stand, all in tandem.

•

FIGURE 9—The finishing train is composed of five four-high stands, with provisions for the future addition of another stand.

No slab pusher or turn-tables are installed on the mill, as slabs are available in widths up to the maximum that can be rolled on the strip mill, thus eliminating the necessity for broadside rolling.

Adjustable side guards guide the slab over the tables between roughing stands.

Between the roughing and finishing trains there is a delay table about 160 ft. long, equipped for pneumatic cooling, and so driven by two motors as to permit moving the strip back and forth to give proper temper-

ature control. This table conveys the strip at speeds of 100-400 ft. per min.

The finishing train is composed of a two-high 24 in. x 56 in. scalebreaker placed 19 ft. 6 in. ahead of five four-high 21 in. and 46 in. x 56 in. finishing stands on 18 ft. 6 in. centers. Provision has been made for the future installation of an additional four-high stand to the finishing train. The scale-breaker is driven by a 400 hp., 300-900 rpm., 500 volt d-c. shunt motor through a double gear reduction. The first four finishers are each driven by a 3370 hp., 225-450 rpm., 500 volt d-c. shunt motor, while the fifth stand is a direct drive from a 2800 hp., 168-336 rpm., 500 volt d-c. motor.

Gear ratios, roll speeds and strip speed in the hot mill are as follows:

	Motor rpm.	Gear ratio	Roll rpm.	Strip speed, ft./min.
Roughing scalebreaker	500	17.55	28.5	179
No. 1 Rougher	500	20	25	210
No. 2 Rougher	500	20	25	210
No. 3 Rougher	500	13.1	38.1	320
No. 4 Rougher	500	6.4	78	428
Finishing scalebreaker	300/900	12.85	23.3/70	147/440
No. 1 Finisher	225/450	4.4	51.1/102.2	280/560
No. 2 Finisher	225/450	2.74	82.2/164.4	450/900
No. 3 Finisher	225/450	1.89	119/238	655/1310
No. 4 Finisher	225/450	1.518	148/296	812/1625
No. 5 Finisher	168/336	Direct	168/336	925/1850

Reductions imposed on the strip in passing through the hot mill average about as follows:

Roughing scalebreaker	9 per cent.
No. 1 rougher	33 per cent.
No. 2 rougher	38 per cent.
No. 3 rougher	37 per cent.
No. 4 rougher	36 per cent.
Finishing scalebreaker	4 per cent.
No. 1 finisher	45 per cent.
No. 2 finisher	45 per cent.
No. 3 finisher	35 per cent.
No. 4 finisher	22 per cent.
No. 5 finisher	10 per cent.

Electrically operated loopers are placed between finishing stands to take up any slack occurring between stands.

Screwdowns on the 2-high roughing stands are driven by one 35 hp. d-c. motor, connected together by manually operated slip clutch. Screwdowns on the 4-high stands and the finishing scalebreaker are driven by two 25 hp. d-c. motors joined by magnetic clutch. Remote screwdown position indicators are provided.

All rolls in both roughing and finishing trains are hydraulically balanced. Two-high stands are equipped with oil-film bearings, while roller bearings are used on both work rolls and back-up rolls in the 4-high stands. Roller bearings are also used on the edgers.

Scale is removed from the strip during its passage through the hot mill by hydraulic sprays located at each scale breaker and at each roughing stand. Water is supplied from two centrifugal pumps of 800 gal. (U. S.) per minute capacity at 1000 lb. per sq. in. pressure, each driven by a 700 hp. motor. A hydropneumatic accumulator supplies peak demands, and also controls, through pressure control switches, the operation of automatic bleed valves in the pump discharge lines. Sprays are controlled from flag switches in the mill table which actuates the solenoid of an automatic air valve which in turn, operates the hydraulic control valve.

MOTOR ROOM

The motor room parallels the hot mill building, and is 45 ft. wide x 760 ft. long. All hot mill drives are housed in this room. Reduction gear sets and pinion stands are located in the hot mill building. In the motor room are also the two 5500 kw. dual motor-generator sets, each driven at 360 rpm. by an 8000 hp. 11,000 volt synchronous motor, which supply 500 volt d-c. power for the finishing train drives. Three 1500 kw. motor-generator sets are installed to provide 230 volt d-c. power for auxiliary use, as well as the various small units required for auxiliaries and for control purposes. Two 11,000 volt feeders, carrying all power for the blooming mill and the hot strip mill, terminate at a large 18-unit, remote controlled metalclad switchboard, located in this room and having a rupturing capacity of 500,000 kva. at 11,000 volts.

The positive and negative electrically-operated breakers for the d-c. circuits of the finishing train are of high rupturing capacity, and are aligned on opposite sides of the motor-room basement. They are controlled from the operating desk in the finishing pulpit, from where the finishing motor speeds are also controlled and adjusted.

The motor-room is ventilated and the rotating machinery cooled by a circulating system in which air passes from the room down through the machines, travels through surface-type coolers, and is returned to the motor-room. A make-up fan draws air through filters into the motor-room.

One end of the motor-room bay is devoted to a hot mill roll shop, containing one 48 in. roll grinder and one 50 in. x 240 in. roll lathe.

Strip is delivered from the hot mill at speeds up to a maximum of 1850 ft. per min., in either sheet or coil form. Cut lengths of from 9 ft. 9 in. to 32 ft. may be produced by the drum type flying shear located 12 ft. 8 in. back of the last finishing stand, and arranged for synchronization with mill speed. The shear is designed for a maximum strip thickness of $\frac{3}{8}$ inch. Coils, 30 in. inside diameter x 54 in. outside diameter x 12-50 in. wide, may be formed from stock up to $\frac{1}{4}$ in. maximum thickness on two down-coilers located about 350 ft. beyond the finishing train. From the coilers, material is conveyed by chain conveyor either to the hot rolled finishing department or to the cold mill building.

About 120 ft. beyond the coilers there is a piling unit for cut lengths. The runout table, some 480 ft. long from finishing train to piler, is composed of table rollers with individual squirrel-cage motor drives, drawing power from two variable frequency sets. It is further planned to install an additional cooling table about 700 ft. long, paralleling the runout table, to which it is

to be connected by a 175 ft. transfer. This equipment will give the plant facilities for producing plates.

Steel temperature is carefully watched through the rolling process, radiation pyrometers being installed on the delay table between the roughing and finishing trains, and at the end of the finishing train.

The hot strip mill was designed for a nominal monthly capacity of 50,000 tons. Product may range 12-50 in. wide x .049-.250 in. thick, but averages 37-40 in. wide by .078 in.

HOT FINISHING

Complete equipment for hot-rolled finishing is installed in a building bay paralleling the hot mill. There are two 2-high 27½ in. x 56 in. skin pass mills, one of which is equipped with an uncoiler and tension reel, so that either coils or sheets may be rolled. The second unit handles only cut lengths. The former is driven by a 300 hp., 400-800 rpm., 500 volt d-c. motor, with a 100 hp., 300-1200 rpm., 500 volt reel drive, all under Ward-Leonard control. The mill runs at roll speeds of 42.4-84.8 rpm., giving strip speeds of 311-622 ft. per minute. The second mill is driven at speeds of 21.1-50.2 rpm. by a 200 hp., 400-950 rpm., 230 volt d-c. motor, giving material speeds of 152-363 ft. per minute.

The continuous chain-conveyor normalizing furnace, 100 ft. long x 9 ft. wide, is fired with a mixed gas of 300 Btu. per cu. ft. and consumes about 2,000,000 Btu. per ton of sheets. The furnace has a capacity of about 100 tons per day, material moving at a speed of 2-50 ft. per min.

A 4-vat batch-type black pickler is provided, complete with scrubbing, leveling and oiling equipment, to handle sheets up to 50 x 168 in. This machine has a capacity of 20 tons per hour, and is a unit with oval overhead runway along which travel carriers from which the pickling crates are suspended. When the crates reach points directly over the vats, they are lowered into the solution and oscillated through the action of steam cylinders operating under 150 lb. per sq. in. pressure. The tanks are of steel plate construction, lined with rubber, and with an acid-resisting brick. Two trimming and shearing lines are installed, one an up-cut line designed to handle cut lengths of material up to 3/16 in. thick and 50 in. wide producing lengths ranging 2½-20 ft.; the other a flying shear line designed to cut up coiled material up to .14 in. thick in widths of 18-48 in. producing lengths 3½-20 ft. A stretcher leveler and five resquaring shears are also available here.

FIGURE 10—The runout table, about 480 ft. long, is driven by individual motors, with variable frequency control.

CONTINUOUS PICKLING

Coils are delivered to the pickling department from the hot mill by a continuous chain conveyor. Two duplicate continuous pickling lines are installed in a building 90 ft. wide x 620 ft. long extending out from the south end of the cold mill building. Each line consists of a processing uncoiler and leveler, an upcut-shear, and a mechanical stitcher, followed by a looping pit, four acid tanks, two water tanks and the conventional drying, shearing, oiling and recoiling equipment. The tanks are of steel plate construction, lined with rubber and acid-resisting brick. Acid tanks are 61 ft. 2 in. long x 4 ft. 7 in. wide x 4 ft. deep, with a capacity of about 6000 gallons each. Water tanks are 27 ft. 1 in. long x 4 ft. 7 in. wide x 3 ft. 4 in. deep, and hold approxi-

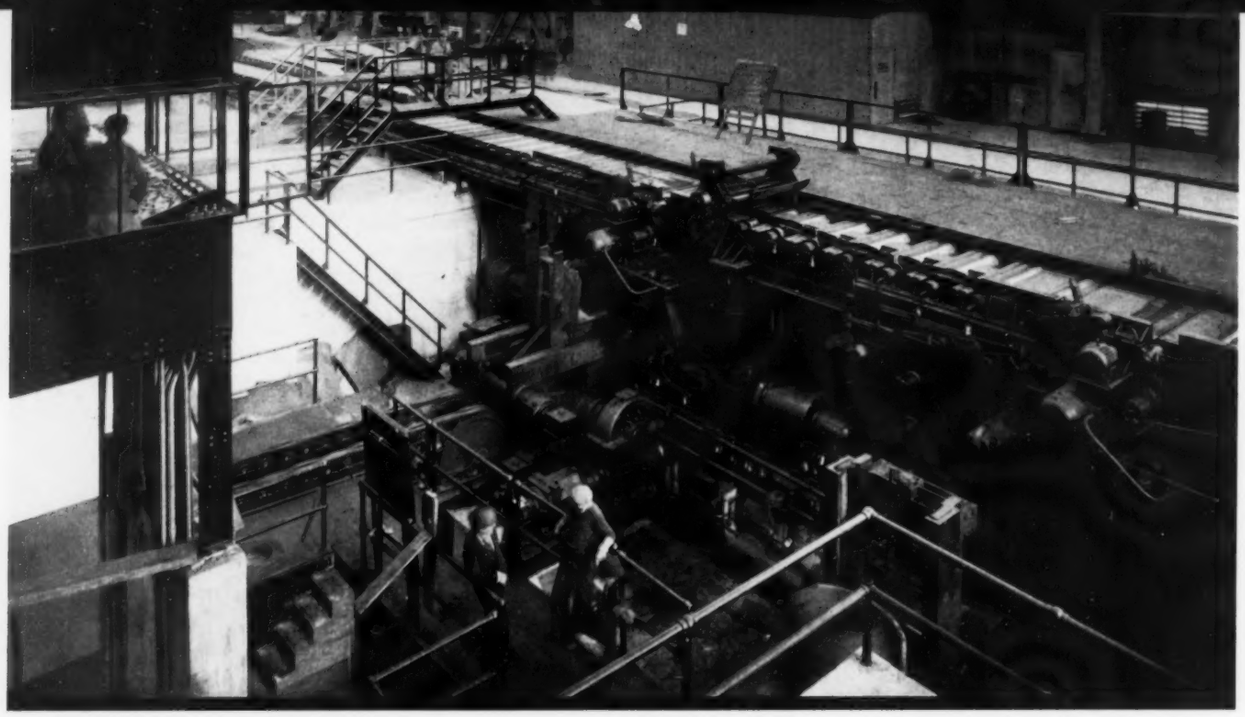


FIGURE 11—Stock up to 1/4 in. thickness may be formed into coils 54 in. outside diameter, 30 in. inside diameter.

mately 3000 gallons each. Tank covers are also of steel construction, rubber lined, and are each vented to the outside through rubber-lined ducts and fan, with an acid scrubber to prevent the discharge of acid vapor to the atmosphere.

Pickling may be carried on at speeds ranging 42-168 ft. per min., in solutions of 10-15 per cent sulphuric acid maintained at temperatures of 175-200 degrees F. by steam jets under automatic temperature control.

This department is rated at a capacity of 35,000 tons per month. Space is available for the installation of a third pickling line if desired in the future.

From the pickling department, the flow line of material through the plant separates, depending on the nature of the product. Coils are moved from the picklers toward either side by gravity conveyors, and carried by ram-type trucks to the cold mill and finishing departments for either sheet or tinplate. These units are housed in a building 1440 ft. long x 515 ft. wide, composed of suitably arranged bays as shown in the general plant layout.

COLD SHEET FINISHING

The cold reduction mill for sheets consists of a tandem mill of three 4-high stands, 19 in. and 49 in. x 56 in., spaced on 18 ft. centers and each driven by a 1500 hp., 350-700 rpm., 500 volt compound d-c. motor. Power for these motors, as well as the 400 hp., 300-1050 rpm., 500 volt d-c. motor driving the coiling reel, is furnished by a 3500 kw. motor-generator set driven by a 3900 kva. synchronous motor. This mill has a maximum delivery speed of about 745 ft. per min., with a

FIGURE 12—Two continuous pickling lines of modern design provide a monthly capacity of 35,000 tons.

nominal monthly capacity of 20,000 tons. Hourly production averages about 30 tons. Strip in widths of 20-50 in. is rolled. Gauges down to .031 in. may be produced in 40-50 in. widths, down to .025 in. in 30-40 in. widths, and down to .015 in. in 20-30 in. widths. Reductions in the mill usually fall between 50 and 60 per cent, running about 30 per cent in each of the first two stands and 10-15 per cent in the third stand. Roller bearings are used on both work rolls and back-up rolls. Two 35 hp. motors operate the screwdowns on each stand. Electric flying micrometers furnish continuous indication of the thickness of the rolled strip.

Gear ratios, and speeds in this mill are as follows:

	Gear ratio	Roll speed, rpm.	Strip speed, ft. per min.
Stand No. 1....	8.12	43 –86	213–427
Stand No. 2....	5.88	59.5–119	296–592
Stand No. 3....	4.68	75 –150	373–745

To dissipate heat generated by the cold reduction of the strip, and to furnish lubrication between the strip and the rolls, a soluble oil solution is sprayed on the rolls at the rate of 500 gpm. The work rolls are also cooled by internal water circulation through the cores of the rolls. Due to the fact that the bulk of the product from this plant is expected to be tinplate, provisions were made so that this mill might also be used for cold reduction of tinplate. Therefore, an auxiliary system was put on this mill for the application of palm oil to the strip in place of the soluble oil.

A cross-rolling mill is also installed, consisting of a single 4-high, 20½ in. and 49 in. x 80 in. mill, on which lengths up to 74 in. may be cross-rolled, producing sheets up to about 74 in. x 110 in. This mill is driven through a 13.8 gear ratio by an 800 hp., 400-800 rpm., 230 volt d-c. motor, giving a roll speed of 29-58 rpm., and a material speed of 155-310 ft. per minute. A minimum gauge of .031 in. may be rolled in widths up to 72 in. The mill has a production of about 3.5 tons per hour when on a six pass schedule, giving a total reduction averaging approximately 60 per cent. Indi-

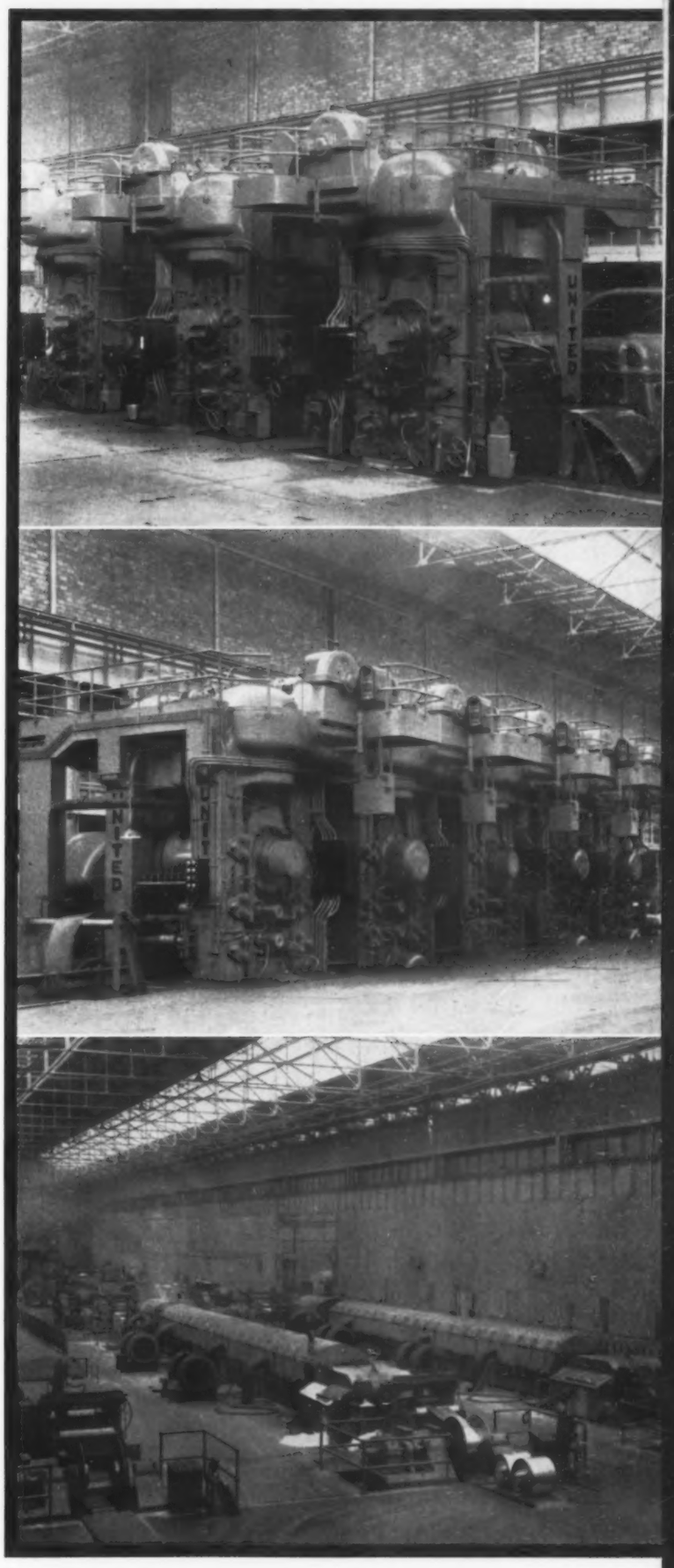


FIGURE 13—A three-stand tandem mill provides a cold sheet reduction capacity of 20,000 tons per month.

FIGURE 14—Cold-reduced tinplate is produced on a five-stand tandem mill, 19 in. and 49 in. x 42 in.

FIGURE 15—Continuous electrolytic cleaning lines remove oil remaining on the strip from the cold-reduction process.

FIGURE 16—Annealing equipment is entirely of the portable cover type, heated by 300 Btu. mixed gas in radiant tubes.

vidual pass reductions in rolling .093 in. material down to .0335 in. are as follows:

Pass	Thickness after pass, in.	Per cent reduction.
No. 1	.078	16
No. 2	.0625	20
No. 3	.0522	16.5
No. 4	.0418	20
No. 5	.0353	15.75
No. 6	.0335	5.25

This mill may also be used for temper rolling.

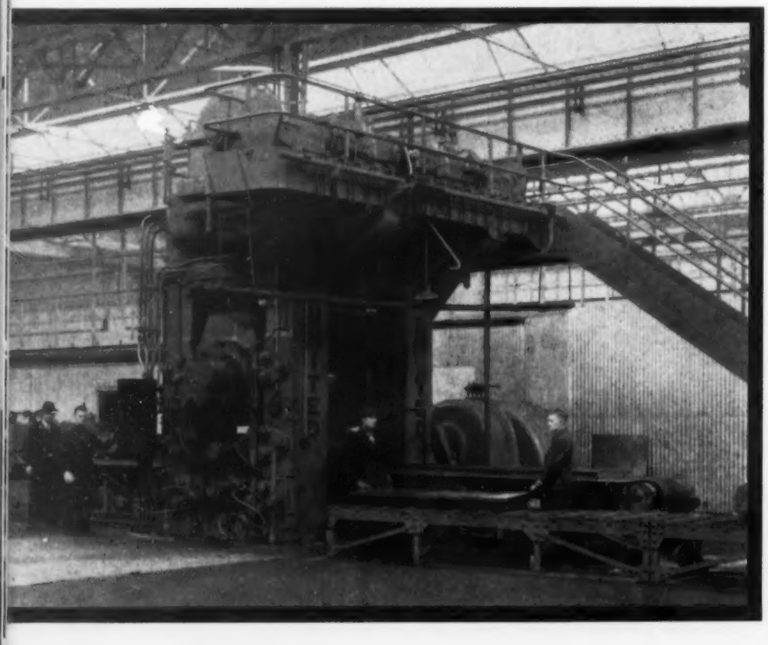


FIGURE 17—Temper rolling of sheets is effected in either of two four-high single stand mills.

From the cold mills, product passes to the annealing department in either coil or sheet form. Cutting lines, consisting of uncoiler, side-trimmer, leveler, flying shear and piler, produce cut lengths at this point if desired. The annealing department for sheets consists of 25 portable annealing covers heated by vertical radiant tubes fired with a mixed gas of about 300 Btu. per cu. ft. The covers operate on 81 bases. Coils up to 50 in. wide, and sheets up to 74 in. x 258 in., may be accommodated. Deoxidizing gas is provided by three gas-conditioning units, each of 15,000 cu. ft. per hour capacity, operating on coke oven gas. Coke oven gas is passed through a series of sulphur purifiers, mixed with a controlled proportion of air, partially burned, scrubbed and dried. The prepared gas is then piped around to the annealing bases in the sheet annealing department as well as in the tinplate annealing department described subsequently.

After annealing, the material is given a skin-pass in either of two 4-high 19 in. and 49 in. x 56 in. single stand temper mills. One mill, driven through a gear ratio of 13.45 by a 200 hp., 400-950 rpm., 230 volt compound d-c. motor at roll speeds of 29.7-70.6 rpm., is arranged for rolling sheets only at speeds of 148-350 ft. per min., and is equipped with a roller leveler in tandem with the mill. The other mill, driven at a roll rpm. of 74.8-149.6 through a gear ratio of 5.36 by an 800 hp., 400-800 rpm., 600 volt d-c. motor, is also equipped with an uncoiler and a tension reel for handling coils as well as sheets, at material speeds of 371-742 ft. per min. The reel is driven by a 400 hp., 300-1050 rpm., 600 volt d-c. motor.

A slitting and side-trimming line is provided for trimming or slitting coils into accurate widths. Other equipment includes two leveling and oiling units, three 60 in. oiling units, a process leveler, a stretcher leveler, a 156 in. shear, three 126 in. shears, and two 74 in. shears.

After completion of the finishing process, material is taken to a large warehouse equipped with temperature control to prevent subsequent rusting of the product.

TINPLATE FINISHING

A complete modern plant for tinplate production has also been installed. Coils, usually of No. 14 gauge material, are brought by ram-type tractors from the continuous picklers to the tinplate cold reduction mill. This mill consists of five 4-high, 19 in. and 49 in. x 42 in.

stands in tandem, the first stand driven by a 400 hp. motor, and each of the last four stands by a 1000 hp. motor, all of 400-800 rpm., 500 volts d-c., compound wound type. The reel for this mill is driven by a 200 hp., 300-1200 rpm., 500 volt d-c. motor. Power for these motors is derived through a Ward-Leonard control system from a 3500 kw. motor-generator set duplicating that used on the cold sheet tandem mill. Material in widths of 12 in. to 38 in. may be reduced to gauges of from .090 in. maximum down to .006 in. minimum. Flying micrometers provide accurate gauge control during rolling. Coils from this mill are 20 in. inside diameter, with a maximum outside diameter of 47 in. Maximum delivery speed from the mill is 1120 ft. per min. Gear ratio mill speeds, etc. are as follows:

	Gear ratio	Roll speed, rpm.	Strip speed, ft. per min.
Stand No. 1	14.52	27.5– 55	137–274
Stand No. 2	8.36	47.9–95.8	238–476
Stand No. 3	5.36	74.5–149	371–742
Stand No. 4	4.04	99 –198	493–986
Stand No. 5	3.56	112–224	560–1120

A typical schedule of reductions for this mill, starting with .078 in., is as follows:

	Thickness, leaving stand	Per cent reduction
Stand No. 1	.0538	31
Stand No. 2	.0312	42
Stand No. 3	.0196	37
Stand No. 4	.0143	27
Stand No. 5	.012	16

Cooling water is applied to the rolls of this mill to preserve roll contour, while palm oil is applied to the strip to improve finish and aid the rolling process. The palm oil-water emulsion is collected, separated, and cooled, so that both the oil and the water may be re-

FIGURE 18—Tinplate material is temper rolled on three four-high 19 in. and 45 in. x 42 in. single stand mills.

used. Both liquids are applied in the mill through specially designed spray nozzles.

Rolls for all cold mills are maintained in a convenient roll shop housing one 48 in. roll grinder and one 24 in. roll grinder, together with a sand-blast equipment and shear knife grinders. Work rolls of all four-high cold mills are equipped with specially designed internal roll cooling equipment, whereby water is introduced into the cored centers of the rolls. A rotating joint permits entrance and exit of the water into the roll in a completely closed circuit.

The cold-reduced material is next transported to the cleaning department, composed of three continuous

FIGURE 19—Each of the five tinplate shearing lines includes an uncoiler, rotary side trimmer, flying shear, assorter and piler.

electrolytic cleaning lines. Adjacent coil ends are electrically welded together, forming a continuous strip which passes through a power washer, an electrolytic cleaning tank, a scrubber and a dryer. The cleaned material, loose-coiled, is then delivered to the annealing department.

Equipment for the annealing of tinplate material consists of nine portable annealing covers, heated with a 300 Btu. per cu. ft. mixed gas burning in horizontal radiant tubes. Thirty-one bases are provided for the covers, each base equipped with fans for circulating hot gases under the welded alloy steel inner-covers. Each base has eight coil stands, a separate inner cover being used for each stand. The entire base is covered by a single annealing cover. Deoxidizing gas is provided from the units previously mentioned, which also supply the sheet annealing department.

Three single stand 4-high, 19 in. and 45 in. x 42 in. temper mills are installed, each driven by a 150 hp., 500-1000 rpm., 230 volt compound d-c. motor, and each equipped with drag uncoiler powered with two 25 kw. drag generators, tensioning rolls powered with a 150 hp., 500-1000 rpm. motor, and a tension reel powered with a 100 hp., 400-1200 rpm. motor, all operating under a Ward-Leonard control system. These mills operate through a gear reduction with a ratio of 5.52:1, giving roll speeds of 90.4-180.8 rpm., and strip speeds of 450-900 ft. per min.

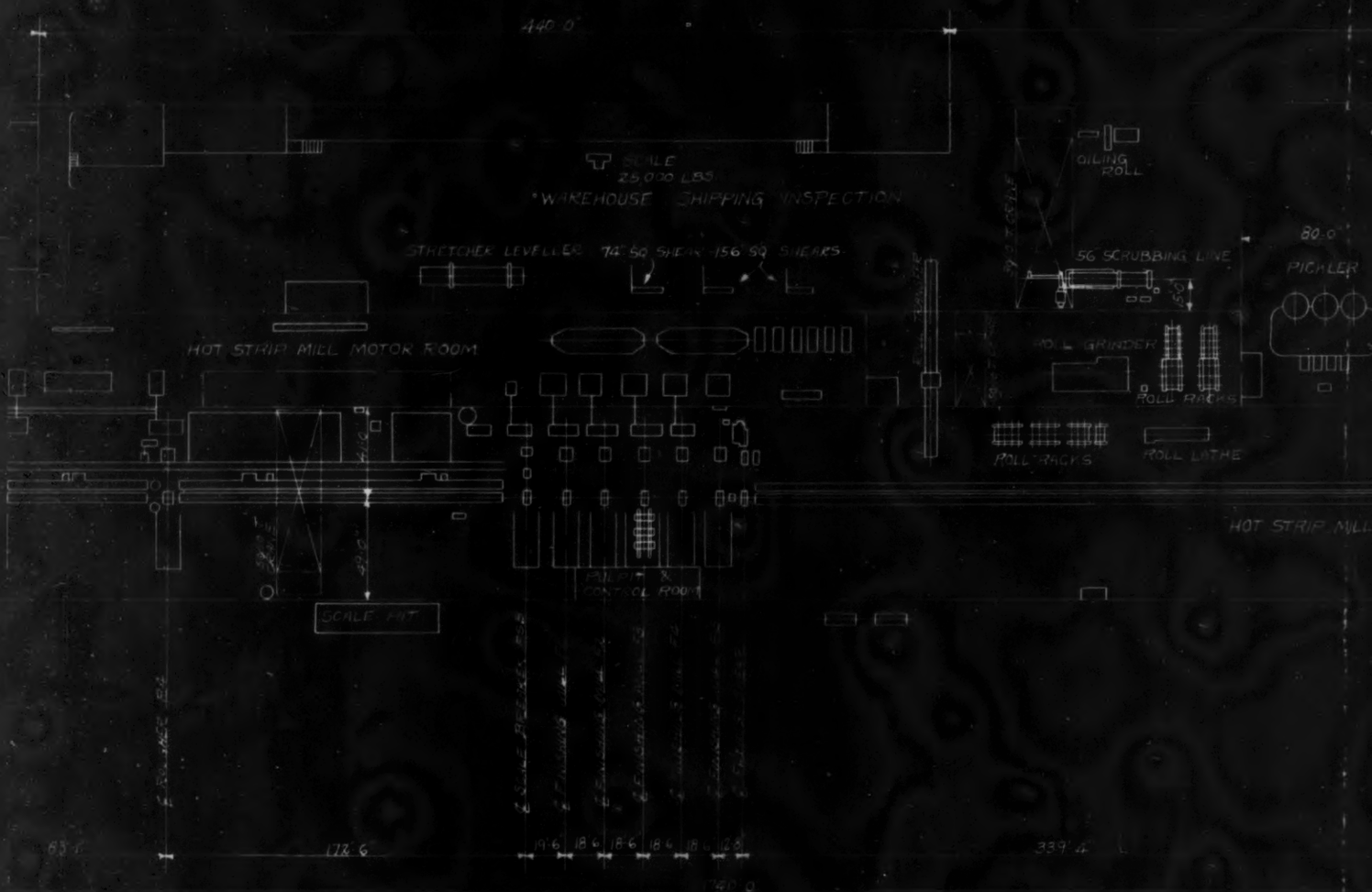
Coils next pass through any of five shearing lines, each consisting of an uncoiler, a rotary side trimmer, a flying shear, an assorter, and a piler. The tinplate is trimmed, cut to length, automatically assorted and stacked. These cutting lines cut lengths ranging 12-52

BUILDING AND CRANE DATA

	Building		Cranes		
	Lgth.	Wdth	Number	Capacity, tons	Span
Slab storage building	560′	100′	1	15	95′-6″
			1	30/10	95′-6″
Hot mill building	1740′	90′	2	50/10	85′-6″
			1	20	85′-6″
Motor room and roll shop	760′	45′	1	50/10	40′-6″
Coil storage	420′	45′	1	15	40′-6″
Hot finishing building and warehouse	1300′	100′	1	30/10	95′-6″
			1	15	95′-6″
Transept building	235′	120′	1	15	115′-6″
Pickling building	640′	90′	2	15	85′-6″
Cold sheet mill building	1440′	90′	1	50/10	85′-6″
			2	15	85′-6″
Sheet annealing	880′	125′	2	40/10	120′-6″
Sheet warehouse	560′	125	1	15	120′-6″
Cold tinplate reduction building	720′	90′	1	50/10	85′-6″
			1	15	85′-6″
Tinplate shearing building	370′	90′	1	15	85′-6″
Tinplate annealing building	720′	90′	1	40/10	85′-6″
			1	15	85′-6″
Tinhouse	640′	100′	1	15	95′-6″
Tinhouse repair shop	290′	35′	1	10	30′-0″
Assorting building	720′	65′	.....	.....	.....
Tin warehouse	720′	70′	1	15	65′-6″
Roll shop and motor room	185′	90′	1	50/10	85′-6″

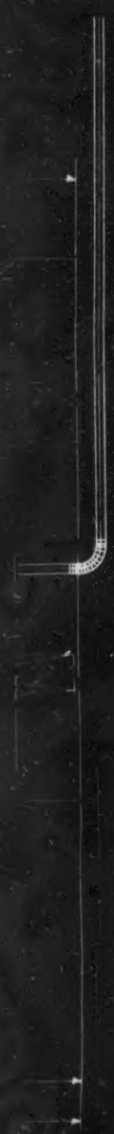
MILL DATA TABLE

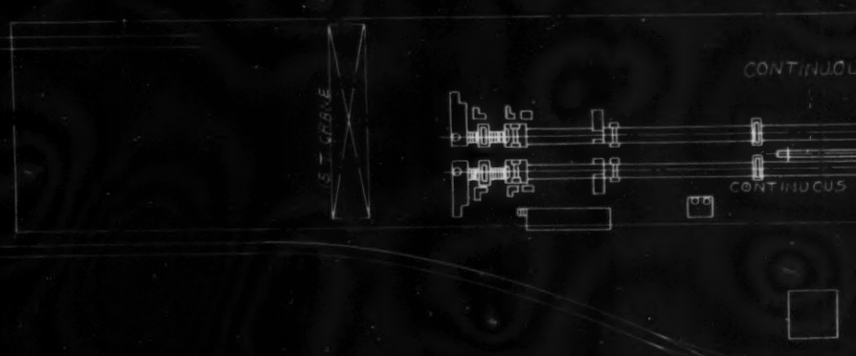
Mill	Characteristics	Roll Diameter		Roll Length	MOTOR DATA				Remarks
		Work Rolls	Backup Rolls		Horse Power	Voltage	RPM	Type	
HOT MILL									
Roughing scalebreaker	1-stand, 2-high	24″	.....	56″	600	440	500	Slip ring	
No. 1 rougher	1-stand, 2-high	32″	.....	56″	2500	11000	500	Synchronous	
No. 2 rougher	1-stand, 2-high	32″	.....	56″	2500	11000	500	Synchronous	
No. 3 rougher	1-stand, 2-high	32″	.....	56″	2500	11000	500	Synchronous	
No. 4 rougher	1-stand, 4-high	21″	46″	56″	2500	11000	500	Synchronous	
Finishing scalebreaker	1-stand, 2-high	24″	.....	56″	400	500	300–900	d-c.	
No. 1 finisher	1-stand, 4-high	21″	46″	56″	3370	500	225–450	d-c. shunt	
No. 2 finisher	1-stand, 4-high	21″	46″	56″	3370	500	225–450	d-c.	
No. 3 finisher	1-stand, 4-high	21″	46″	56″	3370	500	225–450	d-c.	
No. 4 finisher	1-stand, 4-high	21″	46″	56″	3370	500	225–450	d-c.	
No. 5 finisher	1-stand, 4-high	21″	46″	56″	2800	500	168–336	d-c.	
COLD MILLS									
Tandem sheet mill	3-stands, 4-high	19″	49″	56″	(3)1500	500	350–700	d-c., compound	
Cross-rolling mill	1-stand, 4-high	20½″	49″	80″	800	230	400–800	d-c., compound	For sheets only.
Skin-pass mill	1-stand, 4-high	19″	49″	56″	200	230	400–950	d-c., compound	For sheets only.
Skin-pass mill	1-stand, 4-high	19″	49″	56″	800	600	400–800	d-c., compound	Sheets or coils.
Skin-pass mill	1-stand, 2-high	27½″	.....	56″	200	230	400–950	d-c., compound	Hot mill finishing for sheets.
Skin-pass mill	1-stand, 2-high	27½″	.....	56″	300	500	400–800	d-c., compound	Hot mill finishing for coils.
Tandem tinplate reduction mill	5-stands, 4-high	19″	49″	42″	(1)400	500	400–800	d-c., compound	
					(4)1000	500	400–800	d-c., compound	
Tin plate skin-pass mill	1-stand, 4-high	19″	45″	42″	150	230	500–1000	d-c., compound	
Tin plate skin-pass mill	1-stand, 4-high	19″	45″	42″	150	230	500–1000	d-c., compound	
Tin plate skin-pass mill	1-stand, 4-high	19″	45″	42″	150	230	500–1000	d-c., compound	


440'0"
SCALE
25,000 LBS
WAREHOUSE
SHIPPING
INSPECTION
STRETCHER LEVELLER
74" SQ SHEAR
156" SQ SHEARS
HOT STRIP MILL MOTOR ROOM
OILING ROLL
56 SCRUBBING LINE
80'0"
PICKLER
ROLL GRINDER
ROLL RACKS
ROLL RACKS
ROLL LATHE
HOT STRIP MILL
PULPIT & CONTROL ROOM
SCALE PIT
83'6"
172'6"
19'6
18'6
18'6
18'6
18'6
18'8
339'4"
160'0"

PLAN VIEW

NEW HOT *and* COLD STRIP MILLS





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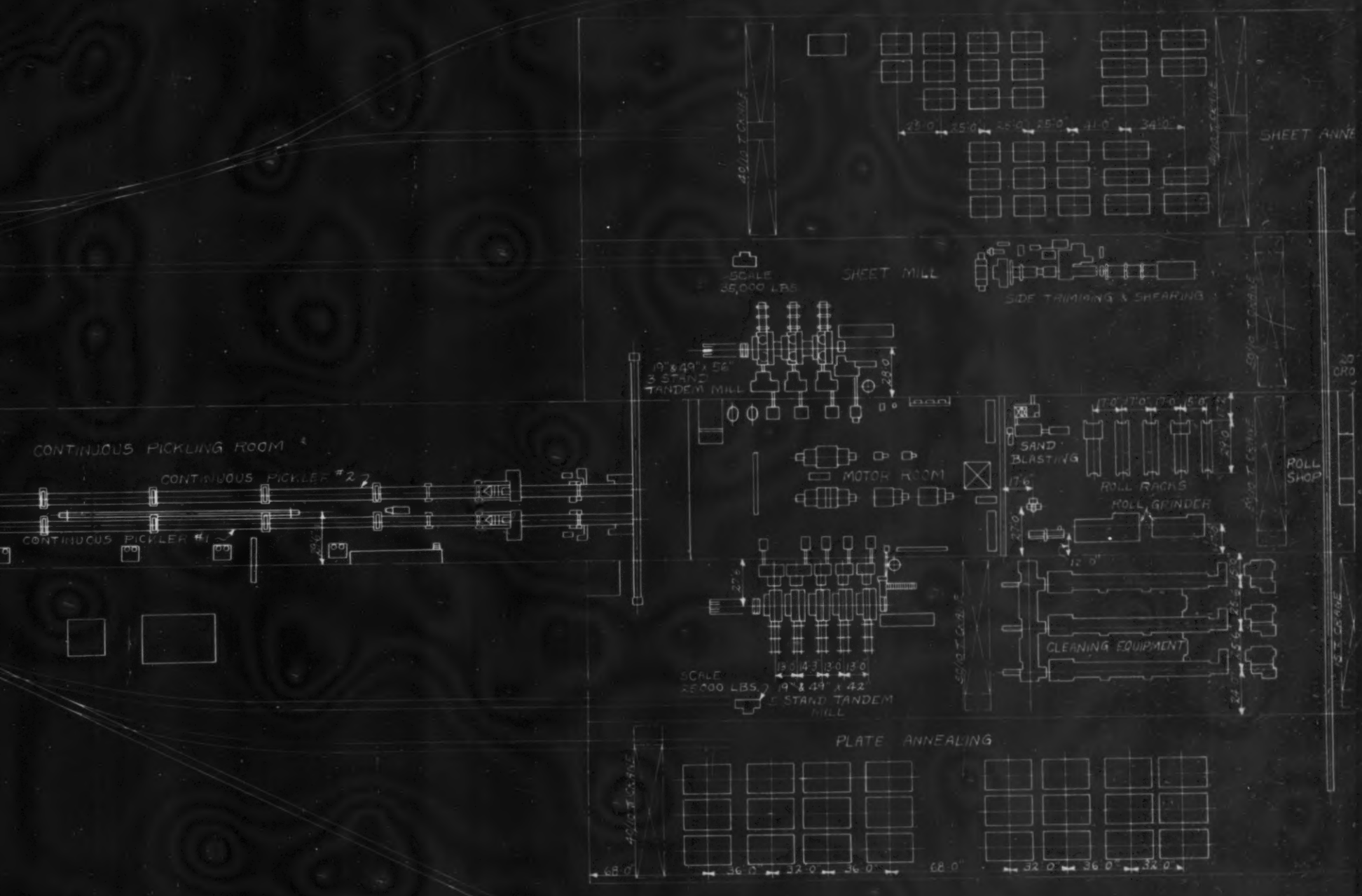
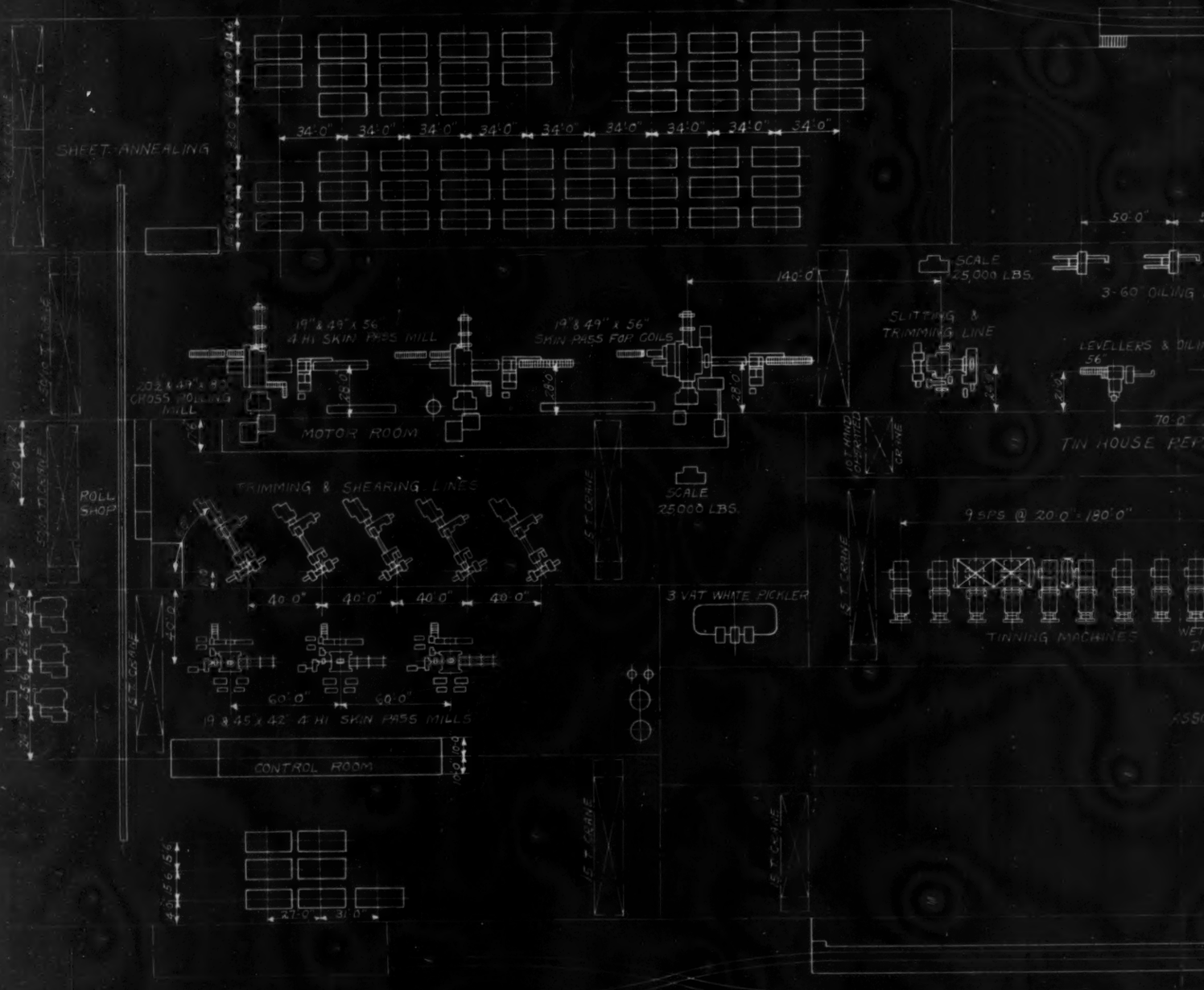
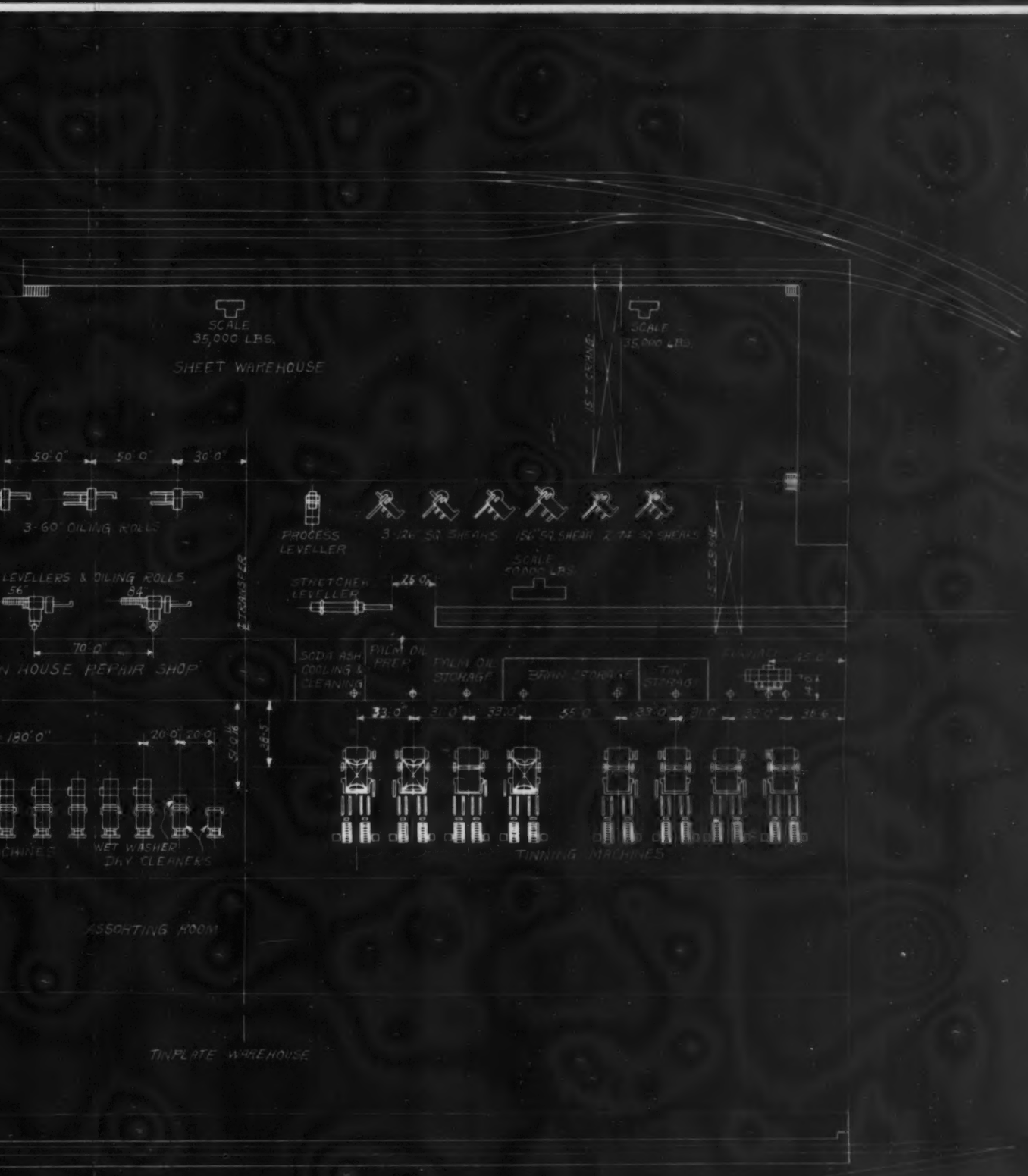
RICHARD THOMAS *and* COMI



COMPANY, LTD., EBBW VALE, ENGLAND


SHEET ANNEALING
34'-0"
34'-0"
34'-0"
34'-0"
34'-0"
34'-0"
34'-0"
34'-0"
34'-0"
50'-0"
SCALE
25,000 LBS.
140'-0"
3-60" OILING
19" & 49" x 56"
4 HI SKIN PASS MILL
19" & 49" x 56"
SKIN PASS FOR COILS
SLITTING &
TRIMMING LINE
LEVELLERS & OILI
56"
20" & 47" x 80"
CROSS ROLLING
MILL
MOTOR ROOM
70'-0"
TIN HOUSE REF
TRIMMING & SHEARING LINES
ROLL
SHOP
S.T. CRANE
SCALE
25,000 LBS.
40'-0"
40'-0"
40'-0"
40'-0"
3 VAT WHITE PICKLER
9 SPS @ 20'-0" = 180'-0"
TINNING MACHINES
60'-0"
60'-0"
19" & 45" x 42" 4 HI SKIN PASS MILLS
CONTROL ROOM
27'-0"
31'-0"


SCALE
35,000 LBS.
SHEET WAREHOUSE
15 T. CRANE
SCALE
35,000 LBS.
50'0"
50'0"
30'0"
3-60" OILING ROLLS
PROCESS
LEVELLER
3-120" SQ. SHEARS
156" SQ. SHEAR & 74" SQ. SHEARS
SCALE
50,000 LBS.
LEVELLERS & OILING ROLLS
56"
84"
STRETCHER
LEVELLER
26'0"
TRANSFER
70'0"
N HOUSE REPAIR SHOP
SODA ASH
COOLING &
CLEANING
PALM OIL
PREP.
PALM OIL
STORAGE
TIN
STORAGE
33'0"
55'0"
180'0"
20'0"
20'0"
WET WASHER
DRY CLEANERS
TINNING MACHINES
ASSORTING ROOM
TINPLATE WAREHOUSE

in. from coils in tinplate gauges and in widths of 12-36 in. A total nominal capacity of about 11,000 tons per month, is available.

Plates ranging 18-40 in. in length by 12-36 in. in width may be tinned. Two processes of tinning are used in the plant, one in which the plate is pickled in the tinning unit itself, and the other requiring separate pickling. The former process is effected in eight six-way machines, in which the plate is automatically fed and continuously pickled, scrubbed, tinned, cleaned and piled. There are two acid tanks per machine, in which the solution is maintained at 200 degrees F. manually. The tin is heated to 550 degrees F. by immersion heaters using premixed coke oven gas and air under automatic temperature control. The palm oil is in separate pots placed in tandem with the tin-pots, instead of in the same pot, as used in other designs. This allows separate heating of the two substances. Cleaning is by the dry method, using middlings or sawdust and pink meal. These units have a monthly capacity of about 14,000 base boxes. In the latter process, pickling is performed in a white pickler consisting of two acid tanks and a rinse tank, all of wood construction, lead lined, 10 ft. 6 in. long x 5 ft. 10½ in. wide x 4 ft. 8½ in. deep. Pickling baths are an 8 per cent solution of sulphuric acid held at 175 degrees F. by steam jets under automatic temperature control. From the white pickler, plate is tinned in nine 64 in. two-way units and one 75 in. two-way unit. The tin is heated to 615 degrees F. by a system duplicating that on the other type tinning units. Cleaning is effected by wet and dry methods, the wet method using a 200 degree F. solution of soda ash, with middlings or a mixture of sawdust and pink meal being used in the dry cleaner. Capacity of the units of this latter type is about 12,000 base boxes per month.

Tinned plate is transported by fork-type tractors to the assorting room, and on into the tinplate warehouse. Both of these departments have automatic control maintaining proper room temperature. Squaring shears, slitters, a leveler and packaging equipment are installed for final processing and packing prior to shipment.

LUBRICATION

Every effort has been made to assure proper lubrication of the new equipment. There are seven central circulating pressure oil systems, completely automatic, with reservoir, pumps, filters, centrifuge, etc. At the point of application, sight feed needle valves regulate the quantity fed to bearings, and specially designed spray nozzles apply oil evenly under pressure to the meshing gear faces. These units, serving about 450 bearings, are as follows:

1. 5,000 gal. storage capacity, serving blooming mill pinions, pinion bearings, and manipulator.
2. 10,000 gal. storage capacity; blooming mill auxiliaries and table gears.
3. 6,700 gal. storage capacity; pinions and pinion bearings of hot strip mill.
4. 8,400 gal. storage capacity; bearings and gears in reduction gear sets of hot strip mill.
5. 1,675 gal. storage capacity; pinion and reduction units of 2-high skin pass mills.
6. 9,200 gal. storage capacity; gears and bearings in pinion and reduction units of 3-stand and 5-stand tandem mills.
7. 6,700 gal. storage capacity; gears and bearings in pinion and reduction units of single stand 4-high cold mills.

There are approximately 16,500 additional bearings requiring grease lubrication. The more important applications are served by seven automatic grease systems operating on a time schedule. These systems serve the following equipment:

1. Blooming mill roll neck bearings, manipulator shear, table rolls, etc.
2. Strip mill furnaces, charging equipment, etc.
3. Plain roll neck bearings of 2-high stands in the hot strip mill; slab squeezer.
4. Screwdown mechanism of all hot mill stands, roll neck bearings on No. 4 rougher, and all finishing stands; hot mill tables, guides, and loopers.
5. Coilers, runout table, conveyors, 2-high skin-pass mills and auxiliaries, shearing lines, etc.
6. Roll necks and screwdowns on both tandem mills, continuous picklers, electrolytic cleaners, etc.
7. Roll necks and screwdowns on single stand cold mills, cutting lines, shears, tinning machines, etc.

POWER AND MISCELLANEOUS

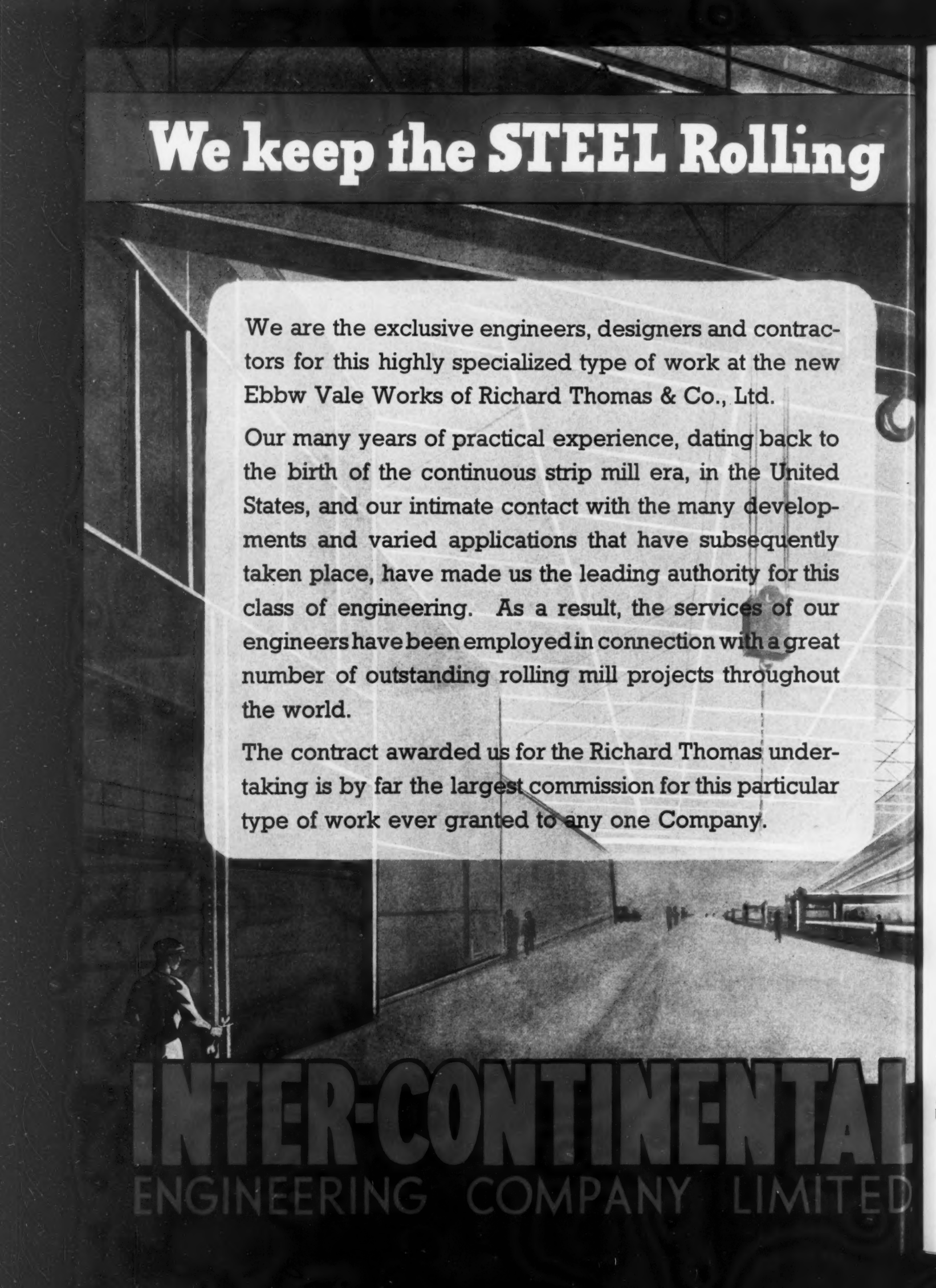
Power requirements, above that produced in the power plant previously mentioned, are met by a connection with a utility company. Line voltage of 132,000 volts is stepped down to 11,000 volts in an outdoor substation of 90,000 kva. capacity. From this station two 11,000 volt feeders are carried to the hot mill motor-room and two to the cold mill.

The connected power load of the sheet and tinplate plant is as follows:

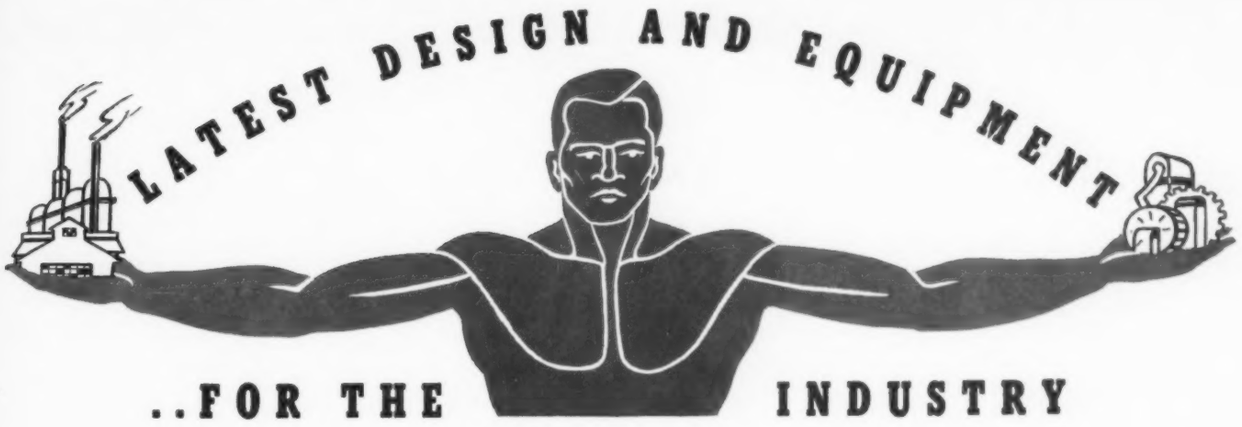
	Kva.
No. 1 scalebreaker, 600 hp. x .746	447
Nos. 1, 2, 3 and 4 roughers, 4 x 2500 x .746	7,460
Finishing train motor-generator sets, 2 x 8000 x .746	11,940
Auxiliary motor-generator sets, 5 x 1700	8,500
Cold mill motor-generator sets, 2 x 3900	7,800
1 x 1000	1,000
3 x 300	900
Auxiliary transformers, 5 x 2000	10,000
8 x 150	1,200
Total 11,000 volt connected load	49,247

Water is supplied from a near-by reservoir holding 270,000,000 gallons. Wherever possible throughout the plant, water is reclaimed and reused.

As previously noted, mixed coke oven gas and blast furnace gas is used to a great extent in the steel and sheet plants. These gases are piped through the plants separately, with automatically controlled mixing stations at the various points of usage. This method allows greater flexibility in the use of these gases than the use of one central mixing station.


We keep the STEEL Rolling
We are the exclusive engineers, designers and contractors for this highly specialized type of work at the new Ebbw Vale Works of Richard Thomas & Co., Ltd.
Our many years of practical experience, dating back to the birth of the continuous strip mill era, in the United States, and our intimate contact with the many developments and varied applications that have subsequently taken place, have made us the leading authority for this class of engineering. As a result, the services of our engineers have been employed in connection with a great number of outstanding rolling mill projects throughout the world.
The contract awarded us for the Richard Thomas undertaking is by far the largest commission for this particular type of work ever granted to any one Company.
INTER-CONTINENTAL
ENGINEERING COMPANY LIMITED

ADVERTISING PAGES REMOVED



DUST COLLECTION SERVICE IMPROVED

▲ The Buell Engineering Company and the B. F. Sturtevant Company have completed arrangements whereby the latter's field organization will parallel the work of the Buell service staff, thus greatly increasing service facilities on dust and fly ash collectors throughout the country.

The present field organization of the Buell Engineering Company, retained intact, will continue to function as in the past. Their testing laboratory with unique equipment for analyzing dusts and predetermining extraction efficiencies accurately, will be complemented by the Sturtevant laboratory. The Van Tongeren laboratory in Holland, which devotes itself to the scientific solution of dust problems and has a permanent staff of 35 engineers and technicians, will cooperate closely with both of the American laboratories.

By such coordination, the two organizations, both national in scope and with long experience in handling dust problems, will bring dust and fly ash collection service closer to interested companies, regardless of location. Also, since their products are complementary, the new arrangement enables the engineer to secure at one time, from a single source, both the dust or fly ash equipment and the fan equipment as a complete system with no division of responsibility.

CIRCUIT BREAKER REDUCES DELAYS

▲Expensive delays and time-out periods, caused by over-loads and short circuits, are eliminated by the new circuit breaker manufactured by Colt's Patent Fire Arms Manufacturing Company. This new breaker, designed to assure industrial protection, is furnished in a variety of types and sizes. The "No-fuse" mechanism is ruggedly built, and the circuit breaker will provide exceptionally long service in steel mills because it is compact, completely enclosed and non-tamperable.

The operation of this new breaker is extremely simple. When circuit is opened, handle automatically indicates "tripped"; after the cause of interruption is removed, handle is manually turned to "reset" and then to "on", and service is restored.

Several different types of enclosures are available, including general purpose sheet steel with grounded neutral, dust-resisting sheet steel, and weatherproof cast iron. The most popular cabinet, general purpose sheet steel, is equipped with heavy-hinged cover and felt gasket to exclude dust; knockouts in top, bottom and sides; cover interlock; black japan or cadmium plated finish.

NEW GALVANIZING UNITS INSTALLED

▲ A new type of galvanizing equipment has been developed by the Wean Engineering Company for the production of exceptionally tight coat galvanized sheets which are used for deep drawing and forming operations.

This new development results in lower dross formation in the pot and a clean sheet is produced. The combination of these two advantages, with a method of controlling the coating, produces galvanized sheets at lower cost.

Four of these galvanizing units complete have been installed at the Steubenville Works of the Wheeling Steel Corporation. Two heavy-duty double bottom roll units have been shipped and installed at the Richard Thomas and Company, Ltd., at Ebbw Vale, Wales, for the coating of air raid precaution heavy gauge sheets. The Steel Corporation of Bengal, in India, is also installing four of the same type galvanizing units, and an additional unit is now being built for the Tata Iron and Steel Company, Ltd., Jamshedpur, India, this making the third galvanizing unit installed in the latter plant within the last few

years. These units have all been supplied by the Wean Engineering Company.

T. C. I. TO INSTALL ORE CONDITIONING PLANT AT MINE

▲ Tennessee Coal, Iron and Railroad Company plans to construct a central ore conditioning and sintering plant at Wenonah Ore Mine No. 7. For the past several years the company has been giving considerable study to improved methods of preparing its iron ore for efficient smelting in its blast furnaces. Extensive research has resulted in this decision to install equipment of sufficient capacity to handle the company's current ore requirements.

Ore will be loaded directly into railroad cars at the mines and transferred to the central ore conditioning plant, where the ore will be dumped into primary crushers. After preliminary crushing, the ore will be conveyed by belt conveyor to a second crushing station for final reduction. Leaving the secondary crusher, the ore will go to a screening and continuous sampling station where it will be separated into three sizes—coarse, medium and fine. Crushing ore at the individual mines will be discontinued.

Coarse and medium grade ores will be sent to storage in steel silos, and chemical analyses will be made while the ore is held in storage. For removal to blast furnaces, ore will be fed from silos by proportional feeders according to definite standards of chemical analysis. The fine grade ore will be conveyed from the screening station to storage bins at the sintering plant. Flue dust from the company's blast furnaces and coke braize also will be stored in adjacent bins. A portion of the fine ore will be mixed with the flue dust and coke braize and sintered.

Some alterations of ore stocking facilities at the Tennessee Coal, Iron and Railroad Company's Fairfield blast furnaces will be required to coordinate the ore conditioning program. It is estimated that the plant will be ready for operation by late summer or autumn of 1940.

ADJUSTABLE SPEED FOR A-C. MOTORS

▲ An all-electric, a-c., adjustable-speed drive which employs a proven principle of speed control heretofore confined to large units has been developed by the Reliance Electric and Engineering Company.

The new drive consists of a control unit and an adjustable-speed motor which is applied directly to the machine to be driven. This speed-changing combination is intended to bring to motor users having only an alternating current power supply an economical means of varying the operating speeds of their small motors (from one hp. up) over as much as a 12 to 1 range.

NEW STYLE OILER REDUCES WASTE

▲ A new line of visible automatic constant level oilers, with unbreakable reservoirs and adjustment oil level features, has been introduced by the Trico Fuse Manufacturing Company. The oiler automatically maintains the proper oil level in ring or ball bearings, gear and pump housings, thereby reducing maintenance expense, bearing failures, waste of oil or grease, oil-

soaked motor windings, damage to materials, fire hazards, and other dangers which accompany the old-fashioned, antiquated, hand-oiling methods.

One filling of the unbreakable reservoir is sufficient to lubricate a bearing three months or longer, without attention. The visible oil supply tells at a glance when refilling is necessary. The reinforcing ribs of the reservoir give added strength, streamlined appearance, and offer a good grip when handled.

The reservoir is attached to the lower casting by the threaded spout. It is easily removable for convenient cleaning and refilling, a valuable feature when installed in dark or awkward places. The capacities are one, two, four and eight ounces, with all bottles interchangeable. Two styles for standard surge and high surge levels having side outlets only and also side and bottom outlets for bottom connection or for draining purposes.

HEAT INSULATION OFFERS ADVANTAGES

▲ A mineral insulation for industrial furnaces and boilers is available under the trade name Falex. This material, a vermiculite product, is made from genuine zonolite selected ores, the granules being formed by multiple expansion of the ore by the application of heat in specially designed processing furnaces.

It is claimed that Falex vermiculite offers a three-way heat saving to a greater extent than any other insulation: (1) The multiple dead air cells in the granules prevent transfer of heat by conduction. (2) The highly reflective surfaces in the granules prevent heat loss by radiation. (3) The granules pack snugly, forming a barrier to heat flow by convection through the insulation.

The material is chemically inert, and will not deteriorate, corrode or affect any material with which it is in contact. The granules are rot-proof, fire-proof, dielectric, odorless, clean, vermin-proof, and extremely light in weight. It may be used without damage to the material or impairment of its efficiency at hot face temperatures up to its fusion point of 2250 degrees F.

The granular material is used on furnace roofs either loosely or covered by a plastic coating. It may be used as a filler for light weight concrete, or with any suitable binder. It is unexcelled for loose fills between brickwork and steel casings, and is widely used for retarding the rate of

cooling of objects requiring a slow cool.

Falex is also available in the form of plastic coatings, blocks and brick. Further detailed and specific information on the product is available from the Faville-Levally Corporation, 140 South Dearborn Street, Chicago, Illinois.

CONTINENTAL TAKES OVER TUBE MILL LINE

▲ The industrial equipment division of the Continental Roll and Steel Foundry Company at East Chicago, Indiana, has acquired the Howell Engineering Company of St. Charles, Illinois, and will manufacture the welded tube mill machinery made under the B. F. Bower patents and patents pending. The engineering, service and sales staffs have become part of the Continental organization.

Included in this company's line of tube mill machinery are high production welded tube mills which produce tubing in a wide range of diameters from flat stock at speeds up to 60 feet per minute, delivering tubes of any predetermined length by means of a flying saw; hydraulic tube bending machines for bending unfinished tubing to any desired angle without crimping or marring the surface; and tube buffing and polishing machinery which continuously and automatically buffs and polishes either straight or tapered tubing.

The tube mill machinery will be produced exclusively at the company's East Chicago plant. The other plants at Coraopolis, Pennsylvania, and Wheeling, West Virginia, will concentrate on castings and equipment for industrial use.

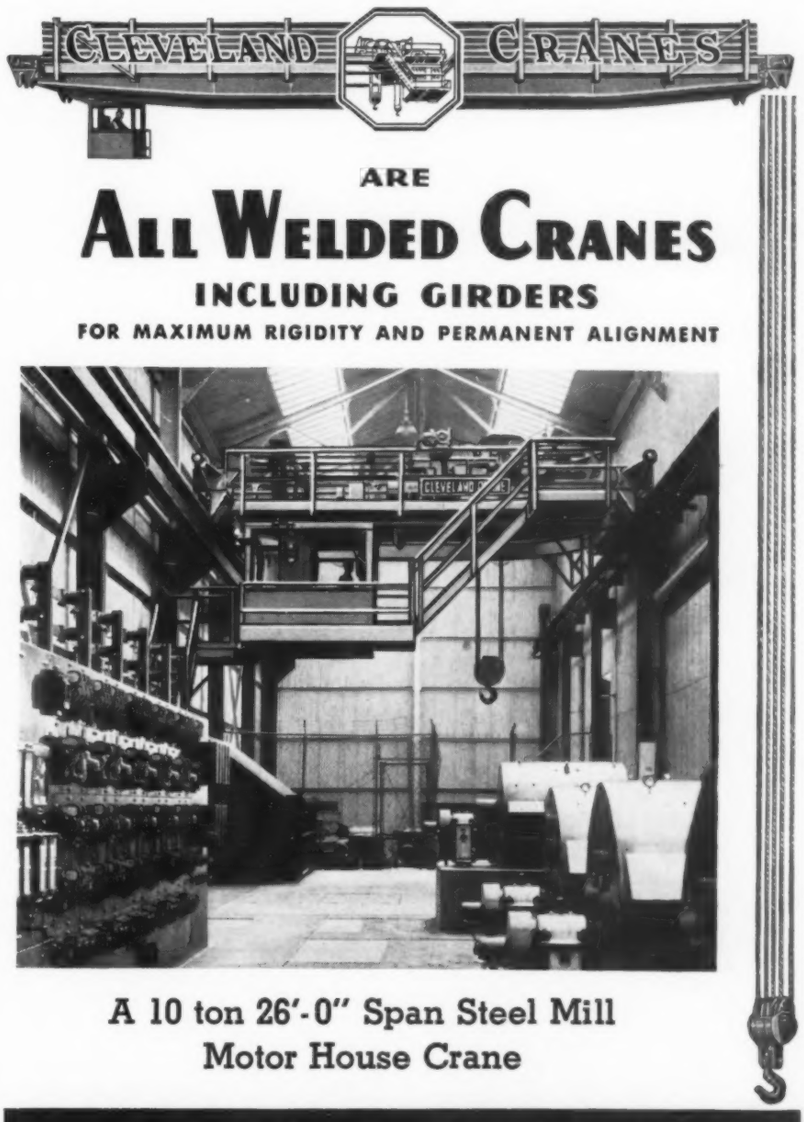
KOPPERS ACQUIRES BEARING LICENSE

▲ Exclusive United States license for the manufacture and sale of multiple oil film bearings has been acquired by the Koppers Company, and these bearings will be produced by the company's Bartlett-Hayward Division in Baltimore. These bearings will become a companion product to the self-aligning coupling which the organization has been manufacturing for many years.

Manufacturing rights and facilities have been obtained from the Fast Bearing Company. Machinery is being moved to the Bartlett-Hayward plant where production will soon get under way.

This bearing, like the coupling, is self-aligning and carries the load on an oil film which prevents metallic contact and wear, and eliminates vibration and noise. It employs the hydrodynamic theory of lubrication based upon Newton's law of viscous resistance of liquids. A load bearing oil film is automatically maintained over the full bearing surface, since each bearing is so designed that it acts as a centrifugal force feed pump, drawing the oil from a reserve supply in the bearing housing and returning it at the end of the cycle. The surplus oil acts as a cooling medium for the bearing surfaces, eliminating high local temperatures in the oil film.

It is stated that these bearings, in a sealed housing, will run continu-

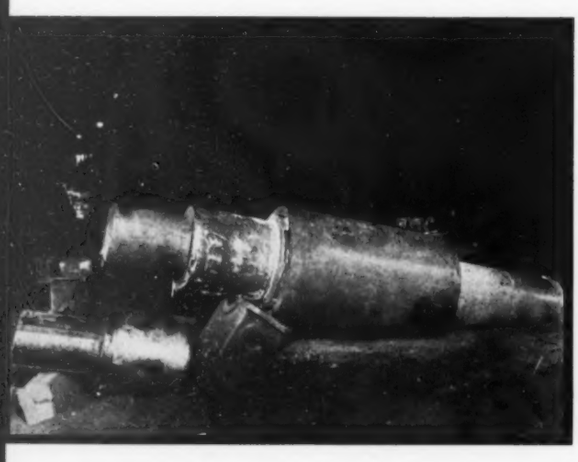

CLEVELAND CRANES
ARE
ALL WELDED CRANES
INCLUDING GIRDERS
FOR MAXIMUM RIGIDITY AND PERMANENT ALIGNMENT
A 10 ton 26'-0" Span Steel Mill
Motor House Crane
ALSO BUILDERS OF CLEVELAND TRAMRAIL MATERIALS HANDLING EQUIPMENT
THE CLEVELAND CRANE & ENGINEERING CO.
1131 Depot St.
WICKLIFFE, OHIO.
NEW YORK DETROIT PITTSBURGH CHICAGO

ously for a year on a single filling of oil. Load capacities are said to increase with speed, due to the intensified pumping action in maintaining the oil film. They also are said to provide high operating economy because of their long life, minimum depreciation and low oil consumption.

NEW TECHNIQUE FOR ROLL REPAIR

▲ Repair of broken roll necks by means of a special foundry burning technique has been developed by the Fulton Foundry and Machine Company. From two to five tons of Meehanite Metal are used for each roll in order to make a good fusion to the roll body. The fusion is carried out at a temperature slightly higher than the melting temperature of the parent metal in the rolls. So complete is the union that after grinding no dividing line is visible.

The roll shown in the illustration is a repaired back refiner roll used in a rubber reclaiming plant. In the foreground may be seen the broken roll neck which has been successfully replaced by the fusion process. The roll had a 24 inch diameter by 36 inch face back refiner roll used in conjunction with a somewhat smaller front roll; the rolls, in operation, being set close together and creating pressures of from 90,000 to 110,000 pounds on each neck or journal. Bearing temperatures often reach 300 degrees F. due to friction resulting from a differential in speed of the rolls, which is usually three to one.



FACILITIES AT IRVIN WORKS AFFORD CLOSE CONTROL OF QUALITY

▲ Standards of quality set up by the Carnegie Illinois Steel Corporation for the products being rolled at the new Irvin Works are extremely severe. Maintaining such standards requires a high degree of instrumentation throughout the plant, a well trained inspection force and close coordination between the metallurgical and operating departments.

Quality control of finished steel products begins with steel making, through the establishment of basic chemical and physical characteristics which will enable the mills to roll the desired product. No steel is produced at Irvin, most of the slabs being shipped in from the nearby Edgar Thomson plant of the corporation. The quality control setup at Irvin begins in the slab yard to assure that the material to be processed is of the proper quality when it enters the slab heating furnaces.

Every slab in the slab storage building at the mill is instantly identifiable as to analysis, heat and ingot position; and particular care is exercised in making sure that piling is such as to permit the heating furnaces to be charged in proper sequence. Slab conditioning is done by flame scarfing, two beds serviced by 7½ ton gantry cranes providing ample facilities for properly conditioning the slabs before they are transferred to the furnaces.

Instrumentation and analytical control begins at the furnaces. These are triple-fired, zone controlled, continuous units using coke oven gas. Zone firing permits the furnaces to be operated efficiently at varying temperatures and provides for utilizing the maximum flame temperature available in the primary heating zone, while avoiding excessive scale loss at either high or low capacity operation. The secondary heating zone is usually held at a constant temperature and firing rate. Gas and air flows are automatically adjusted to give a slightly reducing atmosphere.

Complete furnace control equipment is installed, the panel boards carrying the combustion control equipment, setting dials, indicating and recording gauges, equalizing valves, air-fuel ratio regulators and other necessary instruments. To assure close coordination between the rolling and heating operations, the furnace operator has on his instrument board a recording pyrometer which shows the temperature being maintained in the soaking zone of the furnaces. This is ordinarily held within plus or minus 10 degrees F.

Temperature is watched constantly. An indicating pyrometer, reading at the floor station and in the pulpit, is installed immediately ahead of the finishing train and the steel is not

In Irvin Works no effort was spared to provide equipment tending to improve quality of the product.

allowed to enter the finishing train until it cools to the proper temperature. The operator therefore adjusts the speed of the tables so that the proper temperature is obtained by the time he permits the steel to move through the 80 in. finishing train. He is in constant communication by telephone with the roughing train and furnace operators to correlate temperatures, slab timing and speeds and is an important link in the chain of quality control set up at this plant.

Working at all times in close cooperation, the metallurgical and operating departments have established a number of inter-related quality control features that are closely watched in the finishing train. These factors are worked out in advance to meet the requirements of the finished product. For example, the crown and finish of the rolls bear a close relation to the uniformity of gauge and finish of the final product and must be varied according to subsequent processing and finishing.

Modern equipment of advanced design on the operators' boards in the finishing mill pulpit provides for close coordination of mill speeds and settings, table speeds, tension and other factors. Roll neck bearings are watched closely, for their condition plays an important part in the uniformity as well as accuracy of gauge of the strip. As the temper of the coil is influenced by the temperature at which it is coiled, provision is made at Irvin to control this factor. The metallurgical department specifies the finishing and coiling temperature and the operating department works out the details as to how it may be attained most efficiently, starting with the temperature of the slab as it leaves the furnaces and adjusting sprays, mill speeds, etc. as required.

A pyrometer is installed between the last two stands of the finishing train to show at all times the temperature of the strip as it leaves the train, and it is interesting to note that this is held within plus or minus 10 degrees F. A second pyrometer is installed just ahead of the coilers, and the actual coiling temperature is held within plus or minus 25 degrees F. The coiling temperature range varies between 1000 and 1350 degrees F. according to the type of steel being rolled and the temper required.

Strip temperature may be controlled after it leaves the mill by a specially designed spray cooling unit consisting of three batteries of nozzles, separated by approximately six feet. The first battery consists of 9 nozzles above the strip and 16 below, the second having 8 and 8, while the third has 8 nozzles on top only. Regulation of these nozzles provides the desired temperature control without interfering with operating speeds, which vary between 1000 and 2000 feet per minute.

The metallurgical department constantly checks the product from the hot mill, samples being taken as soon as the material is cold. Routine tests include Rockwell hardness, tensile strength, ductility and microscopic examination of the structure, depending upon the use to be made of the finished product.

Quality control continues as the strip moves on through the pickling lines toward the cold reduction department. An inspector is on duty at

A SLAB MILL had serious trouble with a dense scale that the high pressure sprays could not knock off. A Hays Supersensitive OT Draft Recorder was installed which revealed a large amount of oxygen being fed into the furnace during the charging period. The pressure was adjusted to plus 5/100 in., water-scale was practically eliminated and production noticeably increased.

Two draft values, two pressure values, two differential values, or a combination of any two of these three values may be recorded. These "OT" Recorders are sensitive enough to register accurately increments of .0025 in. water yet are husky enough to stand up under the jars and dirt of steel mill operation. Write to 955 Eighth Ave., Michigan City, Ind. for Bulletin 37-232.

The HAYS CORPORATION
SINCE 1901
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

the discharge end of both the 36 in. and 80 in. continuous pickling lines at all times, with authority to accept or reject the coils. Constant observation is maintained in the checking of the hot rolled strip for gauge and crown as well as surface. Recording thermometers keep a record of pickling bath temperatures and automatic controls hold this within plus or minus 10 degrees F. The pickling cycle is worked out to fit the concentration of the acid in the tanks. Acid strength and concentration is checked every two hours. Pressure on the breaker rolls at the uncoilers is also watched closely to assure that the strip enters the pickling lines in the best condition for efficient treatment.

In the cold reduction department particular attention is paid to the surface finish of the product as well as to its physical properties, size and gauge. The metallurgical department at Irvin is charged with the responsibility of specifying the type of roll surface to be used for securing the desired finish on the strip, ordinarily calling for a certain type of sand or shot blasting or finish grinding. The operating department keeps a constant scleroscope check on the hardness of the rolls, and changes the rolls as required.

Complete instrumentation is a feature of the panel boards in the cold reduction department, allowing the mill operators to balance and control the screwdowns and roll pressures on all stands, roll speeds, and the tension at the entering and discharge ends of the mills as well as between stands. Flying micrometers at all times show the gauge of the product leaving the mills. Indicating strain gauges built into the mill housings play an important part in adjusting roll pressures. Other factors affecting quality, such as the condition of the roll neck bearings, supply and character of the coolant used, freedom from fog around the mill and other minor items are likewise watched closely.

Cold reduced strip from the 5-stand 42 in. tandem cold mill is ordinarily transferred to the tin plate division of the plant. Material from the 3-stand 84 in. tandem cold mill goes to the cold reduced strip and sheet finishing department. The 54 in. reversing cold mill supplies either the tin mill or the cold mill finishing department. Inspection becomes increasingly severe as the product approaches the final processing operations.

Coiled strip which passes the cold mill inspectors moves on through the electrolytic cleaning lines when it is to be used for tin plate. Here close supervision is maintained over the concentration and density of the electrolyte as well as the current supply. Recording, indicating and control instruments are installed to maintain the desired current density, strip speed and tension on the strip.

In the coil annealing department every precaution is taken to see that proper cycles are followed in accord with established schedules to give the desired structure as specified by the metallurgical department. All pyrometers in the annealing department are checked at least every other day by one of the men in the department, and are under close care by a regular test man to assure consistent, uniform accuracy. The lead wires of the annealing furnace thermocouples are all checked by the reserch department before going into service and the pyrometers are all compared with a standard at least once every two weeks. Each annealing furnace base will carry 16 coils under 8 hoods and a thermocouple is installed under each individual hood even though the entire group is under a single heating cover. Coil temperatures must be held within a plus or minus 10 degrees F. temperature range. Periodic checks are made on the coke oven gas used for heating the furnaces and on the deoxidizing gas used under the hoods covering the coils.

To check on the efficiency of the annealing operations and the response of the steel to the treatment specified, the metallurgical department constantly runs Rockwell hardness test on the coils. Periodic tests are also made on the ductility and structure of the material.

As the stiffness of finished tin-plate is an extremely important item, the metallurgical department watches the temper mills closely, passing only that material which comes within the suitable range of physical properties for the particular part to be made from the material shipped. Every coil is checked, the hardness range varying according to the use to be made of the finished product.

Ductility of the product is checked when necessary by Olsen and tensile tests. Further, in order to guarantee the stiffness required on certain tinplate orders, the metallurgical department makes daily checks on the hardness of samples taken from the assorting room, to make sure that every shipment comes within the hardness range prescribed.

At the shearing lines, flying micrometers operating through delay relays automatically assort the plate by gauge, holding the pack within the allowable tolerance. The shear lines in the tin mill operate at strip speeds up to 350 feet per minute. Even after passing the mechanical assorters, the inspection department subjects the sheared plate to an additional examination for gauge, surface, and squareness.

In the white pickle room, inspectors check the temperature of the bath, concentration of acid and activity of the bath every turn. The tin-plate is also checked every turn as it comes from the tinning machines, to determine the weight of the coating, using the Sellers test. When required, tinplate shipments are classified as to their corrosion resistance by the hydrogen evolution test for use in dry pack, vegetable, fruit or special product canning.

After the finished tin plate has passed the rigid surface inspection to which it is subjected in the assorting room, still further physical tests are applied. Ten plates are taken at random by the metallurgical department from each temper rolling for a final check on the accuracy of the preceding tests and to provide a cross-sectional check on the condition of the plate as shipped. These plates are subjected to the Rockwell hardness test, Olsen test for ductility, and the Schoppers test for stiffness at and, intervals to a tensile strength test as well. Accuracy of the base weight is, of course, checked as a matter of routine and fluting tests are run on certain classes of the finished product.

Practically all the product from the 3-stand 84 in. tandem cold mill as well as a substantial proportion of that from the 54 in. reversing cold mill is delivered to the sheet annealing department for annealing prior to cold finishing. The size and mass of the packs, which are annealed in a controlled atmosphere under hoods, makes particular care essential in time and temperature control. All annealing is done in accord with instructions prepared by the metallurgical department, specifying the temperature and the length of time at which the pack must be held at temperature, together with the heating rate.

Each annealing furnace is equipped

with a two-point recording pyrometer. A thermocouple inserted in the top edge of the pack limits the maximum temperature, which must be controlled within plus or minus 10 degrees F. Another thermocouple, centrally located at the base of the pack, furnishes the control for the soaking time, for all portions of the pack must be held at the prescribed temperature for a definite period. The pyrometer chart serves as a permanent record subject to study.

In order to maintain close control of sheet quality up to the very last, normal practice at the Irvin Works is to require that all temper rolling be done just prior to shipment. Accelerated aging tests, however, are made at the cold strip laboratory to determine the effect of a possible three months storage period at the customer's plant. Duplicate specimens are kept for re-checking.

Routine practice calls for applying the Rockwell hardness and Olsen ductility tests to practically all sheet or strip after temper rolling. Much of the product is subjected to a bulge test, which shows the inspectors how the surface of the sheet will appear after drawing. This test, which can be applied to any type of sheet, is particularly helpful in determining the proper roll finish and has played an important part in the rapid development and progress of deep drawing. These tests are supplemented by pull tests made on longitudinal samples to show up any light coil breaks if they occur. Strain tests are also made on notched samples in a specially designed machine and indicate whether or not the sheet has been temper rolled sufficiently to avoid the occurrence of stretcher strains in subsequent forming operations.

Four laboratories are located in the mill, convenient to the departments which they serve. These, with a main laboratory, provide adequate metallurgical and chemical facilities.

NEW LITERATURE

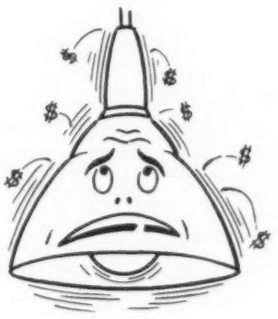
▲ Delta-Star Electric Company has issued a new index which can be used for quick reference to their Catalogue No. 38-D. This index is illustrated in such a manner that convenient reference to the type of equipment will show the name and page number as it appears in the Catalogue.

Copies may be secured from the Delta-Star Electric Company, 2400 Block, Fulton Street, Chicago, Illinois.

▲ Mathews Conveyer Company has published a handbook on conveyers, designed expressly for engineers and plant operating personnel. The book, which is pocket-size, contains over 380 pages of engineering data and information. It should prove very valuable to those who are interested in the mechanical handling of all kinds of material.

Plant operating officials who are vitally interested in this subject should write to the Mathews Conveyer Company, Ellwood City, Pennsylvania.

▲ Rockbestos Products Corporation



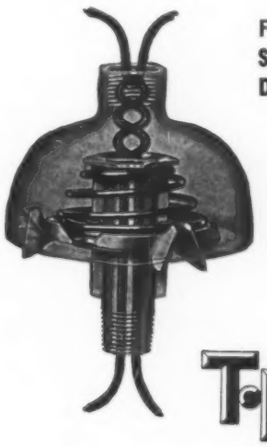
Are

JITTERBULBS

shaking $ out of your pockets?

When lighting fixtures are subject to repeated shock or vibration, they become afflicted with what we term "Jitterbulbs." Connections work loose, lamps flicker and get out of focus, lamp filaments become fatigued and break, far short of their normal life. The resulting frequent relampings and repairs mean wasted $.

This needn't happen!! In hundreds of plants, Thompson Lamp Absorbers are guarding not only lamp bulbs, but the entire lighting fixture, against these destructive forces. Lamp life has been increased as much as ten times and reduced maintenance costs have quickly paid for the installation.



Thompson Lamp Shock Absorbers are designed and manufactured by the makers of Thompson Lamp Lowering Hangers, specialists for 27 years in lamp suspension equipment.

New models and springs have been added, offering a selection to suit a wide variety of installation conditions and fixture weights, and to provide the maximum of floating action.

*The Application of Thompson Shock Absorbers is not confined to lighting fixtures. If shock or vibration is affecting other suspended devices, Thompson engineers will be glad to suggest a solution.

The line of Thompson Lamp Lowering Hangers likewise has been improved and expanded for even better operation and wider application.

If you are not familiar with the new Thompson lines, ask your electrical supply man or write direct.

Be sure you have the new catalogue, No. 39.

THE THOMPSON ELECTRIC CO.

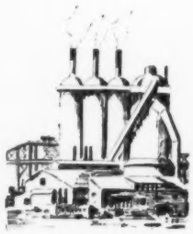
1101 POWER AVE., N. E. CLEVELAND, OHIO, U. S. A.

has issued a new catalogue on permanently insulated wires, cables and cords for industrial uses. The new catalogue illustrates and describes wires, cables and flexible cords designed for use where electric wiring either in conduit or open, is exposed to heat, fire hazard, corrosive fumes, vapors, oil or grease.

Readers desiring copies of this bulletin, entitled Handbook-Catalogue No. 10-E, should write to the Rockbestos Products Corporation, New Haven, Connecticut.

▲ Miller Company, manufacturers of the Ivanhoe fluorescent lighting fixtures, recently issued a bulletin announcing "New Three-Light and 48-Inch Fluorescent Daylight Reflector Units for Industrial Appication".

Anyone interested in this latest information regarding industrial illumination should write to the Miller Company, Meriden, Connecticut.



STEEL

Specifies

DOLPH'S

For many years discriminating electrical engineers in the steel industry have specified the use of DOLPH'S Insulating Varnishes for their electrical equipment. They demand CHINALAK for rewound motors and transformers. They insist on ELECTRIC LACQUER for general maintenance work.

And today the JOHN C. DOLPH COMPANY offers still other insulating varnishes to meet the ever changing demands of this industry. Outstanding among these more recent developments is SYNTHITE No. 153-Y CLEAR BAKING VARNISH. For high speed work or for applications where a more rigid finish is required, this grade is ideal. If your plant engineer is not familiar with this new material, we will gladly furnish him with full details.

JOHN C. DOLPH CO.

Insulation Specialists

166A Emmett Street Newark, N. J.

▲ Westinghouse Electric and Manufacturing Company recently issued a new booklet describing d-c. magnetic crane controllers for hoist, bridge and trolley service. The controllers, for series wound motors, are designed for high speed light hook lowering and dynamic braking. Included in this booklet are descriptions of bridge and trolley controllers for series wound motors, with time limit acceleration and reversing plugging.

Interested persons should write direct to the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania, requesting Descriptive Data 9600.

▲ Leeds and Northrup Company announces a booklet describing a new "Micromax" frequency controller which provides the isolated generating plants with automatic control of frequency which heretofore has been thought feasible for large central stations on interconnected systems.

Copies of this booklet may be obtained by writing to the Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia, Pennsylvania, requesting Catalogue N-56-161 (1).

▲ I-T-E Circuit Breaker Company, located at 19th and Hamilton Streets, Philadelphia, Pennsylvania, has available the following descriptive data:

Catalogue No. 1236—"Automatic Reclosing Circuit Breakers". This booklet describes and illustrates the company's line of KSA switchboard breakers and KSC sectionalizing breakers.

Bulletin No. 1134—"Direct Current Generator Protection". This book describes characteristics of the company's circuit breakers for protection of two and three wire generators, operated either singly or in parallel.

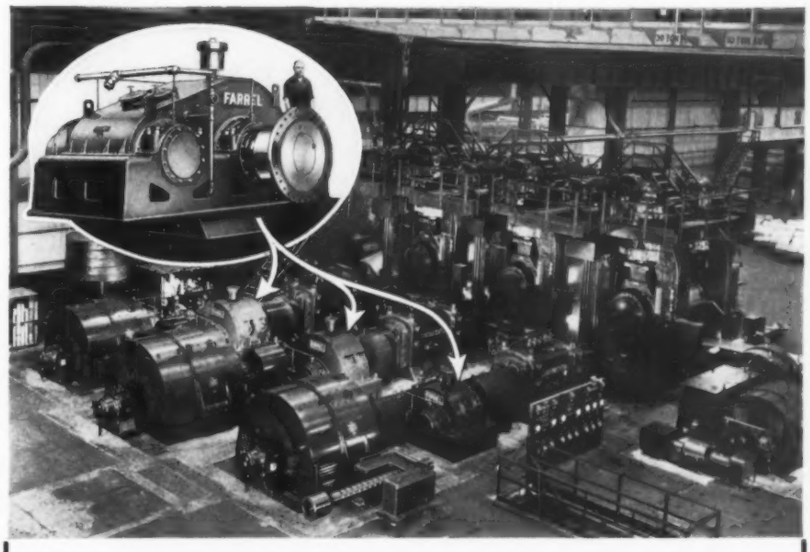
Bulletin No. 936—"Industrial Thermostat Relay." Describes applications and operating characteristics and gives explanatory drawings of this moderately priced, accurate and compact temperature relay for industrial uses.

▲ The bulletins of the Kaiser Wilhelm Institut Fur Esenforschung, 1938 contain a wealth of information. In 1938, the bulk of the subjects investigated was metallurgical, both on the physical and on the chemical side. The mechanical side was less emphasized than in other years. These bulletins can be purchased singly from either the Institute, located at

Dusseldorf, Germany, or from G. E. Stechert and Company, 33 East Tenth Street, New York, New York. Since some readers may be interested in one or another of the bulletins, their titles are given herewith, it being understood that the original text matter is in the German language:

VOLUME 20

1. Fatigue testing of steel wires with varying tensile stress (II Effect of variations in drawing upon tensile strength under fluctuating stress). 2.70 Marks.
2. Alternating stress and state of crystallization. 3.75 Marks.
3. The use of potentiometric analysis in the chemical laboratory of steel plant VIII. (A simplified determination of manganese, chromium, and vanadium, simultaneously). 1.25 Marks.
4. Cold-rolling tests with steel which has been plated with nickel, copper, or brass. 1.80 Marks
5. On the influence of rate of cooling on the transformation of steels (II a recording electric dilation meter, and the influence of slow cooling upon the transformation temperature of carbon steels; III same for a photoelectric instrument). 2.25 Marks.
6. How to save manganese in the open-hearth process. 2.00 Marks.
7. a. The weld-brittleness of chromium-molybdenum steels.
   b. On welding rods for acetylene welding, considering weld-brittleness. 2.75 Marks.
8. On magnetic testing of materials. 2.25 Marks.
9. Comparative investigation on hardness penetration of chromium-molybdenum steels. 4.25 Marks.
10. Austenite transformation in the undercooled state of iron-nickel-carbon alloys. 2.00 Marks.
11. Grain structure and strength of high-grade cast iron. 3.50 Marks.
12. The system iron-rhenium. 1.25 Marks.
13. The influence of electrode diameter (test conditions) upon the mean error in spectral analysis. 3.00 Marks.
14. a. Spreading in rolling high-carbon flat wire from round rods.
    b. Initial diameters in rolling flat wire from round rods. 6.50 Marks.
15. a. The diagram iron-niobium.
    b. The iron corner in the iron-niobium diagram below 1050 degrees C. 3.25 Marks.
16. Effect of rate of cooling upon the transformations and properties of vanadium steels. 3.00 Marks.
17. Alternating stress and state of crystallization II (Crystal deformation in fatigue). 2.00 Marks.
18. A magnetic scale for measuring srturation. Saturation of cementite and carbon steels as a function of temperature and previous history 1.60 Marks.
19. Evaluation of time-stretch curves by different methods for determining fatigue-strength. 3.25 Marks.
20. Work requirements and flow of material in die forging. 5.00 Marks.



FARREL GEAR UNITS

Drive 84" Tandem Cold Mill at New Irvin Works

In the new Irvin Works of Carnegie-Illinois Steel Corporation the 84" three-stand tandem cold reduction mill shown above is driven by three Farrel Gear Units. Two of the stands are powered by 2500 HP motors and the third by a 3500 HP motor.

These drives are typical examples of the advanced engineering and precision construction embodied in all Farrel Gear Units to assure efficient, economical, dependable performance under the most severe operating conditions.

All three drives are single reduction units with cases of all-welded steel construction which combine greater strength with less weight. Gears are continuous tooth herringbone, accurately generated by the Sykes process. Oil is supplied to gears and bearings by a central lubricating system. Built-in sprays lubricate the gears and the bearings are flood lubricated. To prevent oil contamination, dirt and moisture are trapped by breathers mounted on the covers.

Farrel Gear Units are built in any capacity for every type of service. When you have a drive problem ask to have a Farrel engineer consult with you on your requirements.

FARREL

FARREL-BIRMINGHAM COMPANY, Inc.
ANSONIA, CONN.
New York • Buffalo • Pittsburgh • Akron • Chicago • Los Angeles

ITEMS OF INTEREST

Frederic M. Darner chief engineer of Steel and Tubes, Inc., has been appointed to the newly created position of assistant engineer of the Republic Steel Corporation. As assistant to C. A. Thayer, Republic's chief engineer, his duties will be concentrated chiefly on the problems of the subsidiaries and divisions.

A graduate of Case School of Applied Science in 1922, Mr. Darner worked with the American Rolling Mill Company at Zanesville and Middletown, Ohio, and as chief engineer of the Erie Malleable Iron Company at Erie, Pennsylvania. He has been with Steel and Tubes, a Republic subsidiary, since 1933, first as plant engineer of the Cleveland plant, then for the last five years as chief engineer over all plants of Steel and Tubes, Inc.

G. Donald Spackman general superintendent of the Lukens Steel Company at Coatesville, has been granted a leave of absence at his own request in the interest of his health. Mr. Spackman will continue to serve the company in an advisory capacity, and will resume active duty with Lukens when his health permits. A graduate of Swarthmore, he joined the Lukens Steel Company in 1919, serving successively in the mechanical department as fuel engineer, superintendent of flanging department, and assistant general superintendent. When the Lukenweld division of the company was formed, in May, 1930, Mr. Spackman was elected president.

Lester M. Curtiss assistant general superintendent of Lukens Steel Company at Coatesville, was appointed general superintendent in charge of all operations of the company, succeeding G. Donald Spackman. Born at Norfolk, Connecticut, Mr. Curtiss attended Wilson Military Academy, and was graduated from Lafayette College in 1916 with the degree of bachelor of science in chemistry. Following his graduation he joined Merck and Company, Rahway, New Jersey, serving in their chemical manufacturing department. From 1916 to 1919 he was with Harrisons, Inc. at Philadelphia, in the acid manufacturing department. During the war, Mr. Curtiss served as first lieutenant in the field artillery. In 1919 he joined Lukens Steel Company as assistant engineer of tests, holding that position until 1923 when he was made engineer of tests. From 1925 to 1928 he was assistant superintendent of plate mills. He was then appointed superintendent of the Lukens 140 and 206-inch mills, the latter being the world's largest plate mill. In 1932 he was made superintendent of plate mills, in charge of all mills of the company, and in October, 1935 was again promoted to superintendent of production, in charge of all production facilities of the company, which position he retained until his elevation to assistant general superintendent in 1936.

Frank A. Wiley has retired from active service as electrical engineer at the Wisconsin Steel Works of the International Harvester Company. Mr. Wiley was first employed by the Deering Harvester Company of Chicago, from October 1, 1896 to April 12, 1902, in the electrical department serving in various capacities. This company was later absorbed by the International Harvester Company. For a brief period during the year of 1902, he was employed by the Commonwealth Edison Company, also of Chicago.

In October 1902, Mr. Wiley entered the employ of the Wisconsin Steel Works in the capacity of engineer in charge of electrical construction. After the original installation was completed he continued as superintendent of the electrical department. On March 1, 1923, he was appointed electrical engineer of the Wisconsin Steel Works, serving in that capacity up to the present time. His service with the Wisconsin Steel Works is approximately 37 years, with a total service with the International Har-

FREDERIC M. DARNER

G. DONALD SPACKMAN

LESTER M. CURTISS

FRANK A. WILEY

vester Company, its predecessors and subsidiaries, of over 42 years.

In 1909, Mr. Wiley affiliated with the Association of Iron and Steel Engineers, and was instrumental in the formation of the Chicago District Section, where he served as chairman for four years.

B. M. Horter
was named general sales manager for Cutler-Hammer, Inc., Milwaukee, Wisconsin. Mr. Horter, who prior to his new appointment was in charge of the resale sales division at the Milwaukee headquarters, has had a wide background of experience with the company, holding a number of patents on motor control apparatus.

E. W. Seeger
was appointed manager of the development department for Cutler-Hammer, Inc., of Milwaukee. Mr. Seeger was formerly in charge of the production engineering department and will now become responsible for the company's development activities.

P. B. Harwood
has been named manager of the engineering department for Cutler-Hammer, Inc., of Milwaukee. Mr. Harwood has been with the company for over twenty years. After serving in the engineering department he was made assistant supervisor in charge of steel mill control, then general supervisor in charge of engineering. Following this he was made assistant in charge of production engineering department, a position he held until his present appointment.

Henry T. Lintott
was appointed general superintendent of the Columbia Steel Company at Torrance, California. Mr. Lintott, who was born in Visalia, California, studied mechanical and electrical engineering at the University of Nevada. From 1917 to 1922 he served as assistant chief electrician of the Pacific Coast Steel Corporation at South San Francisco. In 1923 he became chief electrician of the Western Pipe and Steel Company also at San Francisco. From 1923 to 1927 he again became associated with the Pacific Coast Steel Corporation as chief electrician and electrical engineer. For the next year, until 1928, he was affiliated with the Lincoln Electric Company of San Francisco. In 1928, Mr. Lintott joined Columbia Steel Company as chief electrician of its Torrance Plant, where he became assistant general superintendent in 1929.

O. A. Kresse
has been appointed assistant general superintendent of the Torrance, California, plant of the Columbia Steel Company. Mr. Kresse was formerly superintendent of the open hearth of that plant.

E. M. Stephens
was made manager of industrial relations for the Columbia Steel Company, Torrance, California. Mr. Stephens has been associated with the steel industry since 1928, when he joined the Chicago Bridge and Iron Company, shortly after graduating from the University of Illinois in structural engineering. For two years he worked in all phases of steel construction and for three years as a contracting engineer in the New York sales office of the company.

In 1933, Mr. Stephens became associated with the United States Steel Corporation as an assistant in the office of the vice-president in charge of sales in New York. In 1936 he joined the industrial relations department in the capacity of assistant to personnel manager. When the United States Steel Corporation of Delaware was formed in 1938 he was transferred to the new organization as assistant director of industrial relations, in which capacity he served until his present appointment to the Columbia Steel Company.

Frank S. O'Neil
has been appointed general manager of the Link-Belt Company's plants in Indianapolis, of which he has been assistant general manager for the past seven years. Mr. O'Neil joined the Link-Belt organization thirty-three

B. M. HORTER

E. W. SEEGER

P. B. HARWOOD

years ago at the company's Chicago plant, where he worked ten years in the foundry, machine shop, cost department, and rate setting and production departments. His Indianapolis plant experience dates back to 1916. the year in which he was transferred from Chicago.

While at Indianapolis, he successively served as assistant superintendent in charge of malleable iron chain assembly, superintendent of the Ewart plant, and assistant general manager of both Ewart and Dodge plants.

Richard P. Brown
chairman of the board of the Brown Instrument Company and vice-president of Minneapolis-Honeywell Regulator Company, has been appointed secretary of the new Department of Commerce of the Commonwealth of Pennsylvania.

C. H. Propper
has been named superintendent of the research laboratory of Carnegie-Illinois Steel Corporation, located in Pittsburgh. For the past seven years Mr. Propper was chief engineer of the C. L. Gougler Machine Company at Kent, Ohio.

D. J. Erikson
was appointed as vice-president in charge of sales for Hagan Corporation and its subsidiary companies. Mr. Erikson will have charge of Hagan automatic combustion control for power plants and for heavy duty furnaces in the steel industry, together with his responsibilities to the other subsidiaries.

D. J. ERIKSON

G. S. Crane
has been appointed vice-president in charge of sales and engineering, for Cutler-Hammer, Inc., Milwaukee, Wisconsin. Mr. Crane, who has been actively in charge of sales, now assumes supervision of all of the development work for this company. Under the new arrangement he assumes executive control of the engineering and drafting departments as well as the patent department.

Mr. Crane has been associated with Cutler-Hammer for 29 years serving successively in the engineering and sales department. In 1931 he was elected to the board of directors and in 1935 was appointed vice-president in charge of sales which position he held until his recent appointment as vice-president in charge of sales and engineering.

Morris E. Leeds
founder and president of Leeds and Northrup Company, is now chairman of the board of directors of that organization. This post is newly created to facilitate Mr. Leeds' participation in policy matters in which he will continue active. A graduate of Haverford College with the degree of bachelor of science in 1888, he taught for two years before entering business. In 1899, Mr. Leeds formed his own company which grew, largely through his inventive talents, from the Morris E. Leeds and Company to the Leeds and Northrup Company, now one of the largest instrument manufacturers in the world.

Charles S. Redding
becomes president of Leeds and Northrup Company, succeeding Morris E. Leeds. Mr. Redding took his first position with Morris E. Leeds and Company, predecessor of the present firm, for fifteen months between high school and college. Receiving a degree of bachelor of science in electrical engineering from the University of Pennsylvania in 1906, he spent two years as instructor in mechanical engineering there, and was briefly associated with the Engineers Club of Philadelphia. He rejoined the Leeds company in 1909, by which time it had become the Leeds and Northrup Company, and has since held executive positions in every division of its activities. He became second vice-president in 1918, was treasurer from 1922 to 1924, and became vice-president in charge of research and engineering in 1928.

MORRIS E. LEEDS

George Schaefer
formerly rolling mill design engineer, has been appointed manager of the rolling mill machinery sales division for the Farrel-Birmingham Company, Ansonia, Connecticut. Other changes in the Farrel-Birmingham organization are as follows:

Norman Shaw
was appointed manager of the company's Chicago office, located at 1059 First National Bank Building, Chicago;

Harry Temporal
has been transferred from the Chicago office to the Buffalo division;

Edward S. Coe
who also has been connected with the Chicago office, is being transferred to the rolling mill machinery sales division in Ansonia.

Samuel L. Hoyt
has become a member of the staff of Battelle Memorial Institute, Columbus, Ohio. Formerly director of metallurgical research with the A. O. Smith Corporation, Dr. Hoyt will act as technical advisor in the planning and conduct of metallurgical research at Battelle. A considerable enlargement of the supervisory and research staff has been made necessary, because the present rapid growth of research activity in industry has led to a marked increased in the volume of sponsored work at the Institute.

Walter F. Perkins
vice-president of the Koppers Company in charge of its Baltimore operations, has been elected a member of the board of directors of the Koppers Company.